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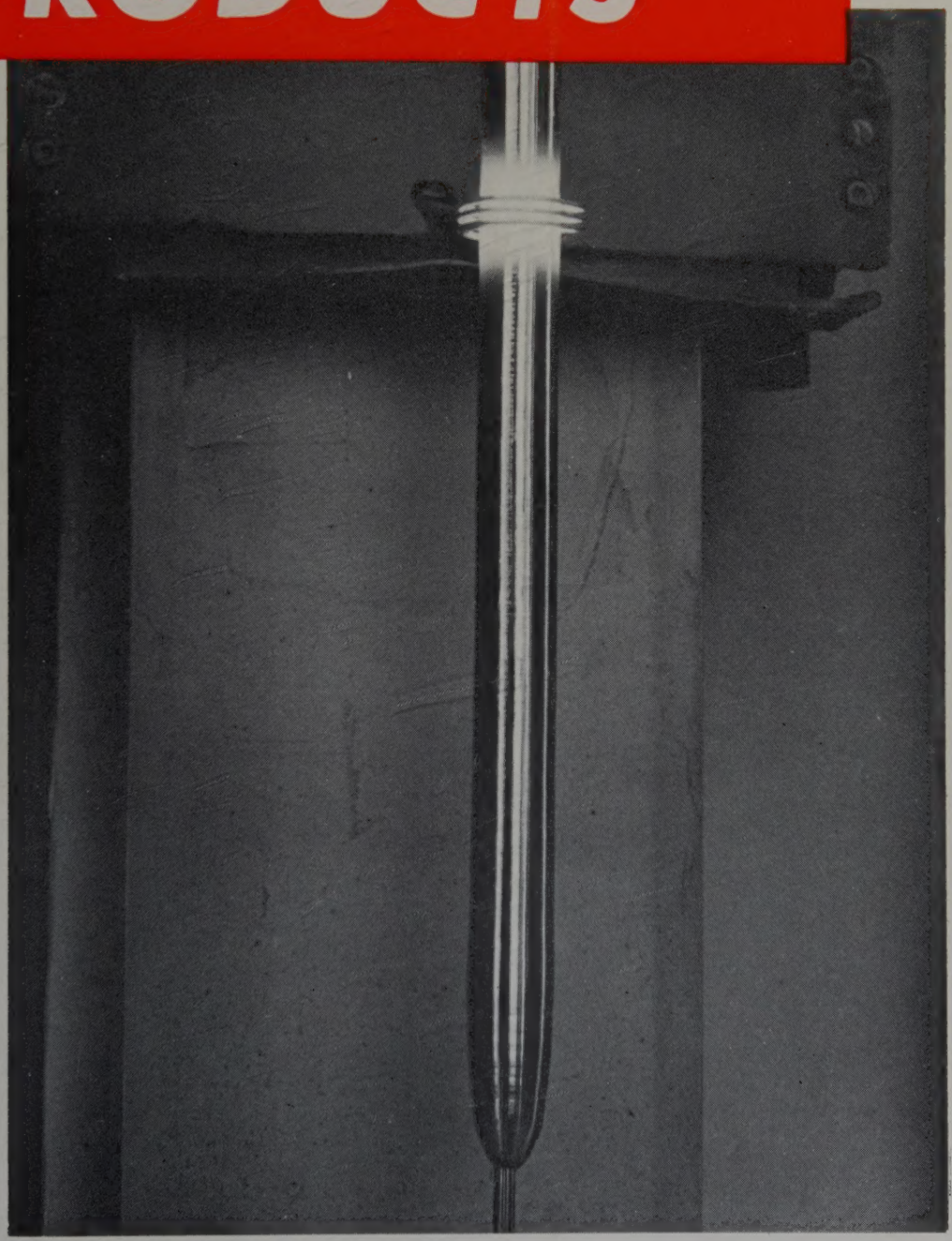

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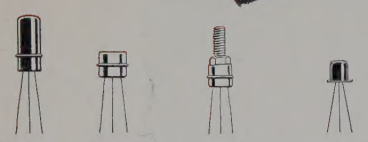

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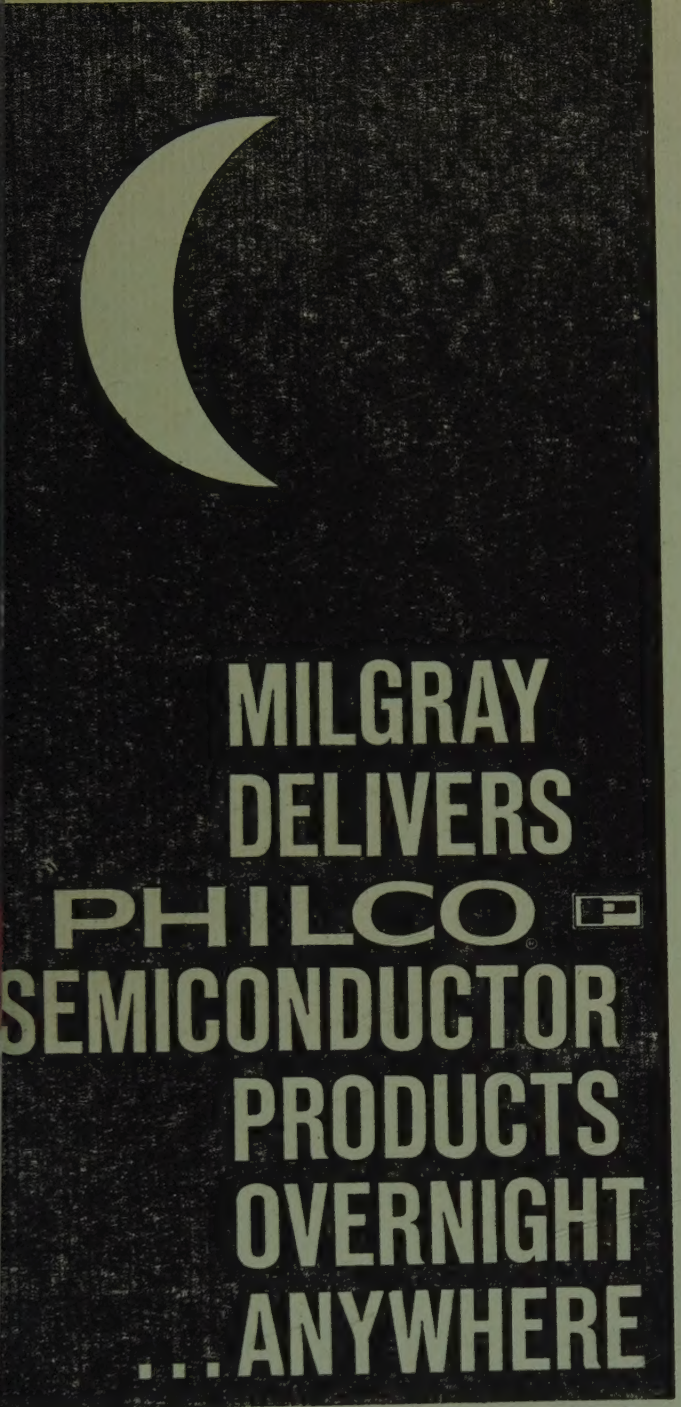


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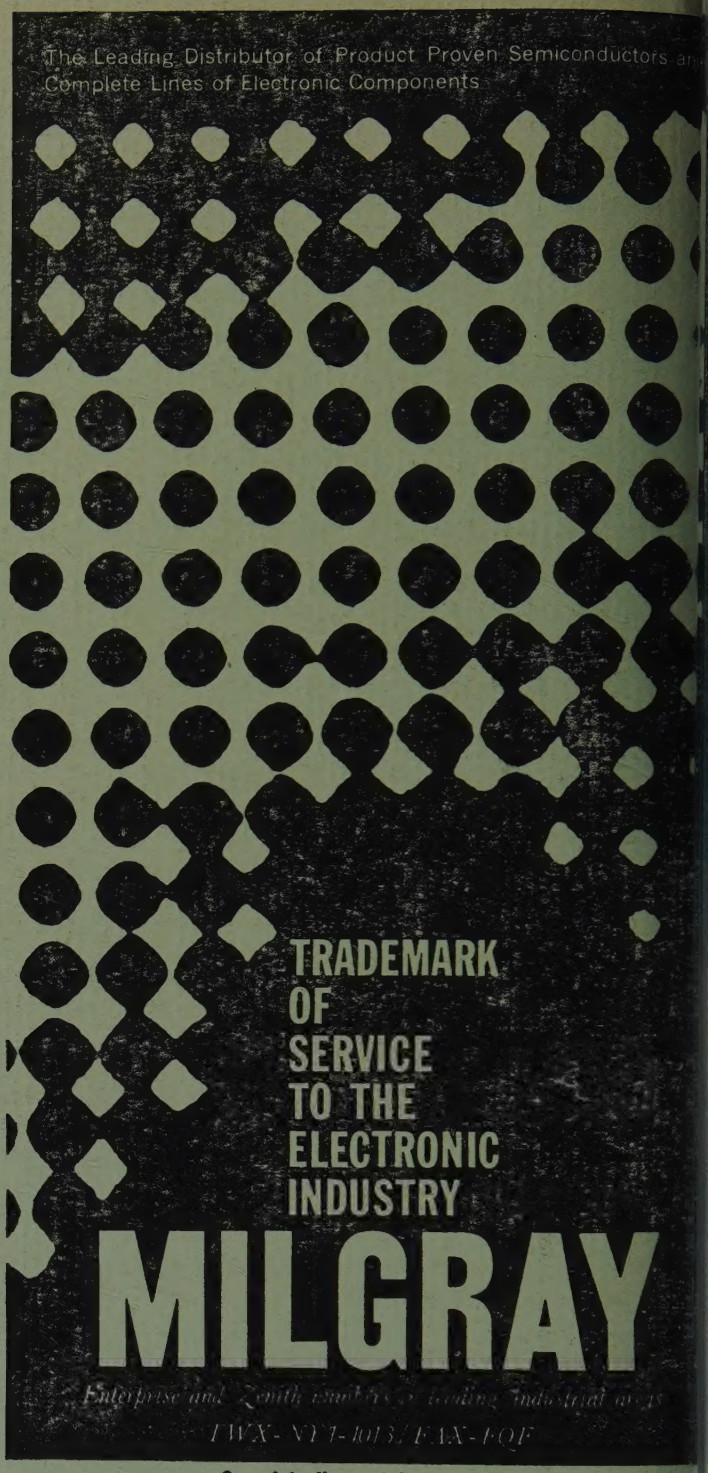


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# SEMICONDUCTOR PRODUCTS

SANFORD R. COWAN, Publisher

April 1961 Vol. 4 No. 4

## CONTENTS

**Editorial** . . . . . 29

**High-Speed Logic Using Low-Cost Mesa Transistors,** *by D. Gipp, R. D. Lohman, R. R. Painter and B. Zuk* . . . . . 31

**A Low-Drift Direct-Coupled Transistor Amplifier For High Temperature Applications,** *by James W. Halligan* . . . . . 35

**Vacuum Float Zone Refining of Silicon,** *by Frank Bourassa* . . . . . 37

**A Graphical Design Procedure for Transistor Resistor Logic Stages,** *by Thomas L. Francis* . . . . . 39

**The Silicon Trinistor, A High-Power N-P-N-P Triode Switch,** *by F. S. Stein and E. W. Torok* . . . . . 42

**A Transistorized Count Rate Meter,** *by Philip Goldstein* . . . . . 46

**Observations On Semiconductor Device Reliability,** *by Harold J. Sullivan and Lowell L. Scheiner* . . . . . 48

**Applications Engineering Digests** . . . . . 51

**Patent Review** . . . . . 53

**Semiconductor and Solid State Bibliography** . . . . . 55

**Characteristics Charts of New Diodes & Rectifiers** . . . . . 60

**Departments**

Book Reviews . . . . . 7

Market News . . . . . 64

Industry News . . . . . 66

New Products . . . . . 68

New Literature . . . . . 75

Personnel Notes . . . . . 77

**Advertisers' Index** . . . . . 78

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**Front Cover**

Transporting hot zone between passes in multiple pass zone refining. Photo courtesy Merck & Co., Inc. (See Article on Page 37.)

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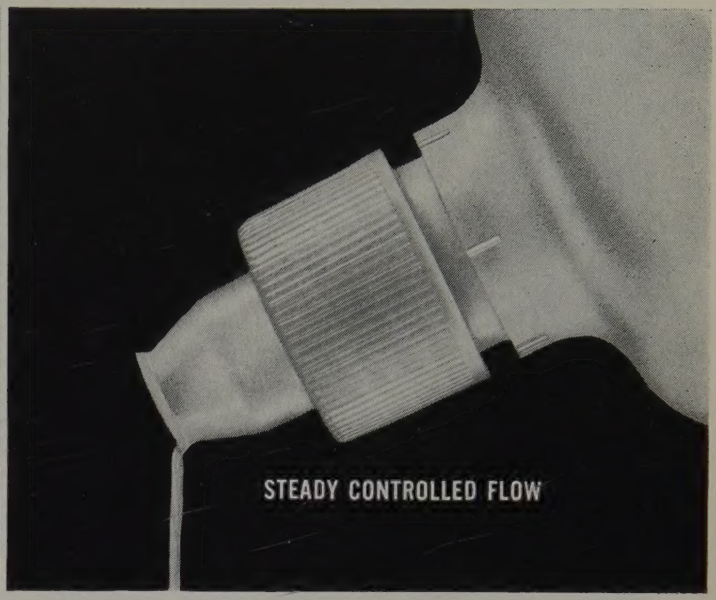


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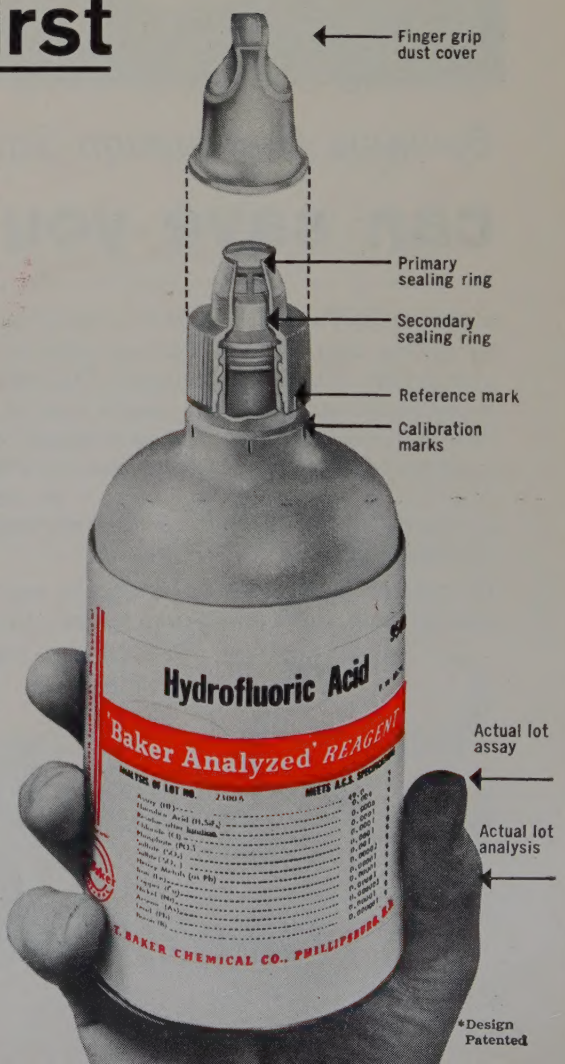


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## In-process testing of silicon diodes with a Type 575

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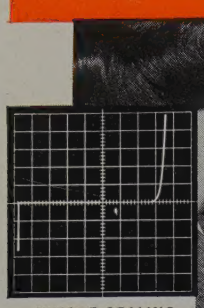

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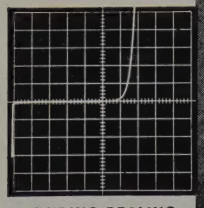

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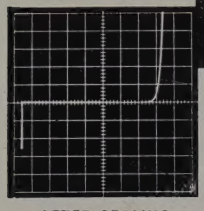

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**NOTE:** Double-exposure waveform photos of the case-sealing operation were taken with control settings at 1 ma/div (v) and 0.2 v/div (h)—forward direction, upper right—and 20μa/div (v) and 20 v/div (h)—reverse direction, lower left.

### . . . in other applications

The Type 575 provides 20-ampere collector displays (10-ampere average supply current), two ranges of collector supply (0 to 20 volts, 0 to 200 volts), and 2.4-ampere base supply (positive or negative base stepping).

With a Type 575, you can plot and measure 7 different transistor characteristics. You can display 4 to 12 curves per family—with input current from 1 microampere/step to 200 milliamperes/step or input voltage from 10 millivolts/step to 200 millivolts/step—in repetitive or single-family presentations. You can select either common-emitter or common-base configurations.

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# Book Reviews...

**TITLE:** Principles of Semiconductor Device Operation

**AUTHOR:** A. K. Jonscher

**PUBLISHER:** John Wiley & Sons, New York

*Principles of Semiconductor Device Operation* is a very comprehensive and well-written presentation of semiconductor physics. The book is divided into six basic sections, each covering a very basic concept.

The first section is an outline of semiconductor theory. The intrinsic semiconductor is studied in terms of the energy level concept. The inhomogeneous $n$ and $p$ type semiconductors are treated as well as the $p$-$n$ junction.

The next section considers the topic on non-equilibrium carrier densities or the concept of generation and recombination of holes and electrons. The steady state recombination is covered in great detail utilizing the idealized Shockley-Read model of a semiconductor. Surface recombination and the concept of lifetime and transient recombination are typical of the material covered. This section is extended in the treatment of the transport of excess carrier densities in the section following.

Chapter IV is a very comprehensive study of the $p$-$n$ junction and junction diodes. A great many topics are covered here that are later used to develop the transistor operation. The $p$-$n$ junction is described in complete detail, starting with the equations for current flow and finally considering reverse bias (Zener) conditions.

The fifth chapter is a description of multi-junction devices (transistors). Here again the physical concept approach is used to describe the electron and hole flow. The book concludes with a chapter on carrier transport in inhomogeneous media.

*Principles of Semiconductor Device Operation* is a particularly good book. It is a well-written and interesting presentation of semiconductor physics that carefully bridges the gap between physicist and engineer.

*By Stephen E. Lipsky*


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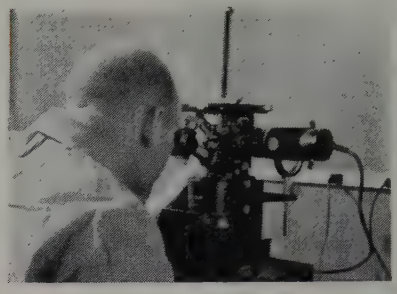

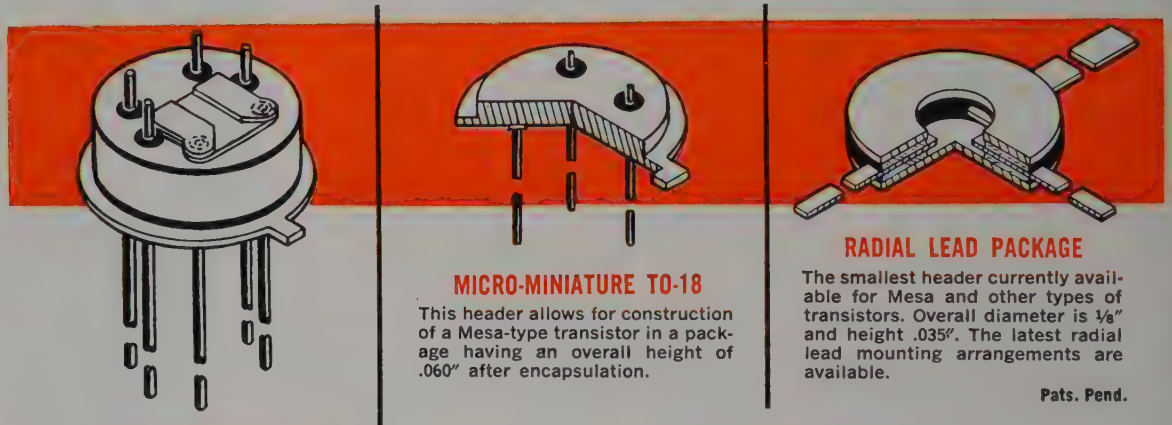

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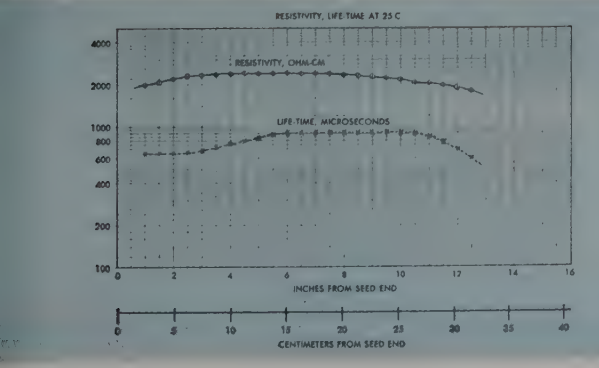
***This highest purity P-type*** silicon is the result of a completely integrated processing facility that starts with the production of trichlorosilane and ends with the crystals heat-sealed in airtight polyethylene envelopes. Purity and quality control dominate every step — in producing the basic chemicals . . . in growing polycrystalline rod . . . in vacuum zone refining . . . in product evaluation and in packaging.

***Purity pays off*** . . . in rectifiers and diodes having higher peak inverse voltage ratings — in maximum utilization because of uniform lateral and radial profiles over the entire length of the rod. With Dow Corning single crystal rod, you're assured of maximum yield and minimum waste per rod. Rod diameter variation is controlled to less than 1.4 mm (0.055 inches) — simplifying mechanical preparation for either the diffusion or alloying process.

***Hyper-pure silicon for every need*** is now available from Dow Corning. If you grow your own crystals from polycrystalline chunk using the Czochralski method . . . if you zone refine polycrystalline rod . . . if you need 1000-ohm centimeter or better resistivity in single crystal P-type — Dow Corning should be on your preferred source list.

Each Dow Corning single crystal rod is checked for resistivity over its entire length. Resistivity and lifetime profiles, like those shown below, are supplied with each crystal.



Write for "Hyper-Pure Silicon for Semiconductor Devices." Address Dept. 8216a.

HYPER-PURE SILICON DIVISION
Address: HEMLOCK, MICHIGAN

**Dow Corning CORPORATION**

MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D.C.

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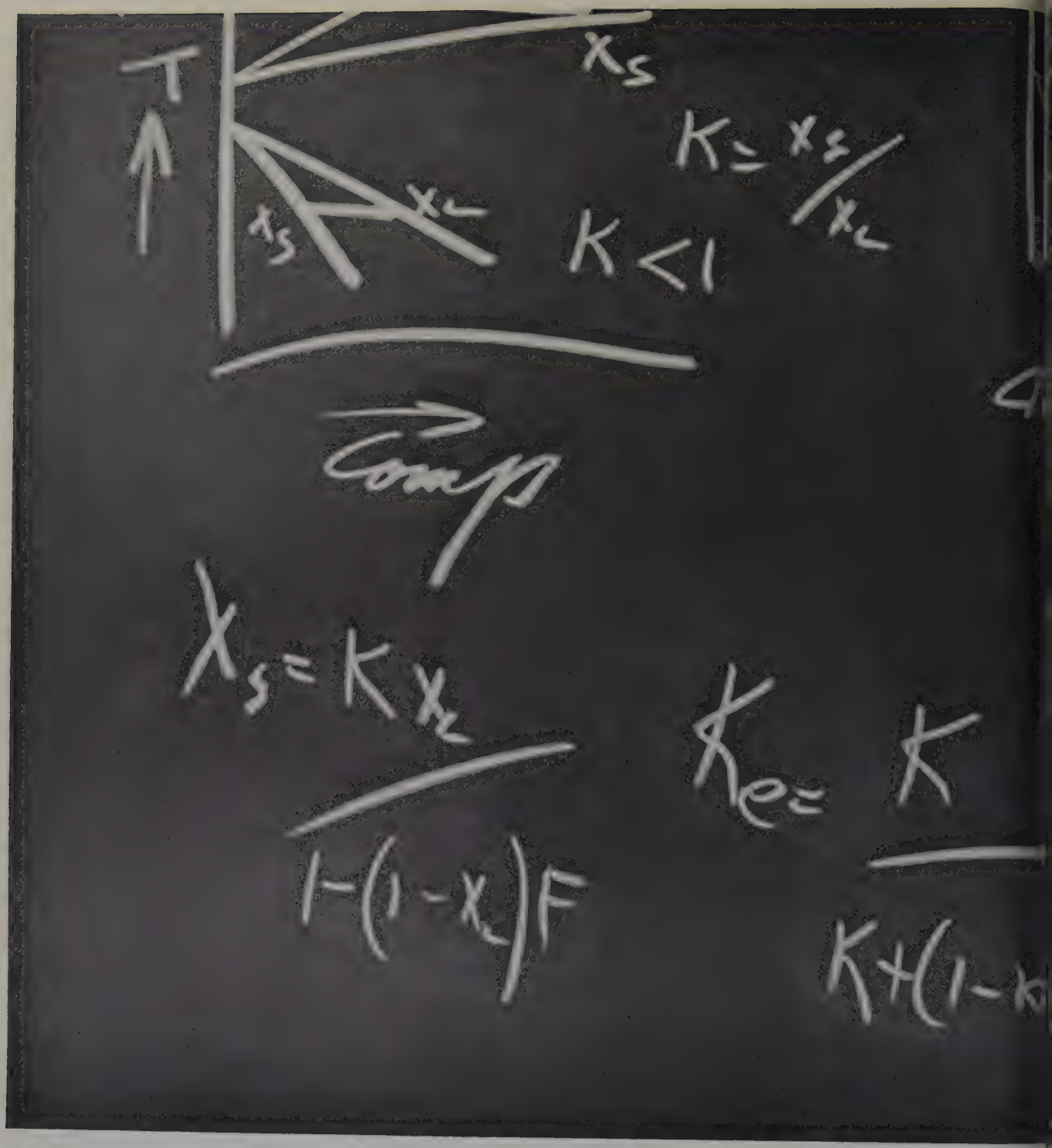


# This is Leonard Bernstein

*He could very well change your ideas about semiconductor materials*

SERVING THE SEMICONDUCTOR INDUSTRY WITH • HYPER PURE DOPING ALLOYS • BRAZING PREFORMS • SPECIAL SOLDER PREFORMS • CLAD METALS • BASE TABS •

ficant changes in semiconductor materials are
to come about quickly at Alloys Unlimited.
reason for this unusual situation? Alloys Un-
ed's new director of research, Mr. Leonard
stein—one of the few materials men in the
try with a thorough background in the prob-
of device design and development.
evice-oriented Bernstein earned his reputation
e of the country's leading semiconductor
facturers where he specialized in alloy de-
velopment and alloy fabrication techniques.

But Mr. Bernstein's presence is just one reason why so many semiconductor engineers prefer to work with Alloys Unlimited. Others include: complete spectrographic analytical facilities, the latest metal purification equipment and a tool and die department second to none in the industry.

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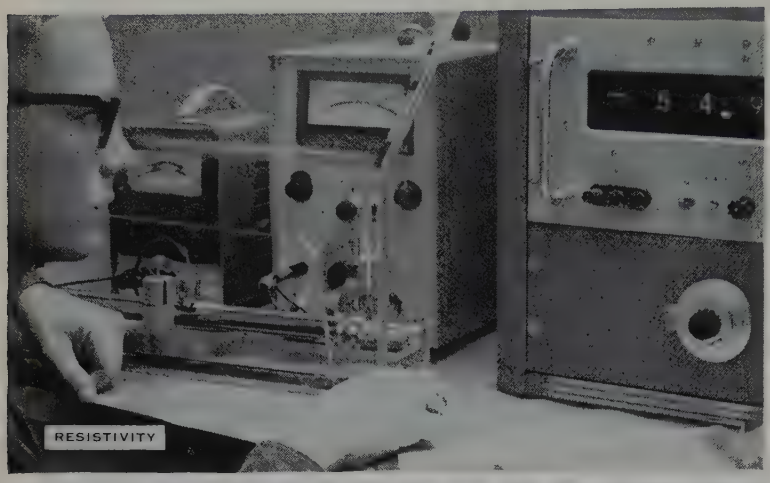
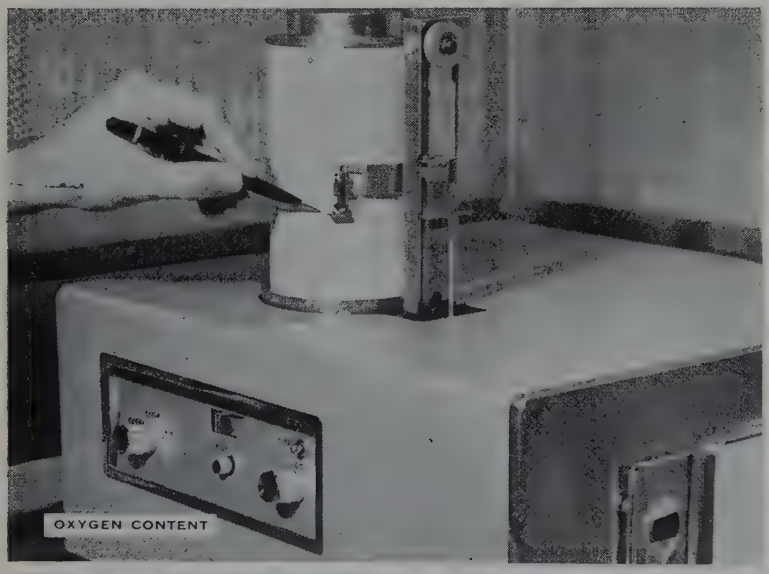
**SILICON NEWS from Dow Corning**

(Part 3)

# The Untouchables

## Now...Single Crystal Silicon Doped to Your Specification



Single crystal silicon . . . doped to your specific needs . . . is now available from Dow Corning.

***Rigid quality control*** of Dow Corning Silicon means greater device yield for you! And you achieve uniformity in device characteristics — the result of greater uniformity in characteristics from rod to rod, greater lateral and radial uniformity within each rod.

***This high quality*** is the result of a completely integrated production process — a process that starts with the manufacture of trichlorosilanes and other chemicals basic to silicon production. And at every step of the way, rigid quality control assures the ultimate in quality—purity.

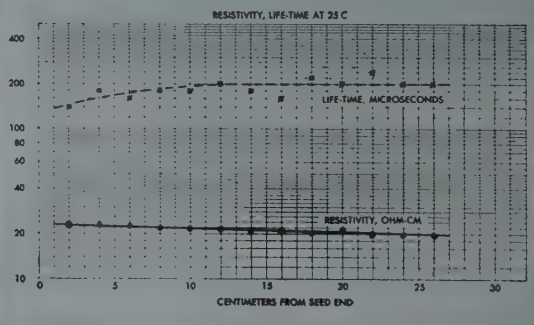
***Doped to specification*** single crystal Dow Corning Silicon contains in the order of 0.1 atoms of minority impurity per billion atoms of P-type material . . . about 0.15 atoms of minority impurity per billion atoms of N-type material.

***Low oxygen content*** of Dow Corning Silicon reduces the undesirable effects on lifetime associated with the diffusion process. Result — few rejects . . . increased device yield! In the picture at left, infrared transmittance at 9 microns is measured to determine oxygen content. Many materials register at pencil point—much higher than Dow Corning Silicon.

***Crystal orientation*** is normally 111, but can be to your specification.

***Specify Dow Corning*** single crystal silicon doped to your requirements. Specific resistivities within narrow tolerances from one to 1000-ohms centimeter P-type . . . one to 400-ohms centimeter N-type. Rod diameters from 3 to 25 mm (1/8″ to 1″) lengths to 250 mm (about 10″).

Whatever your need — polycrystalline rod or chunk; high resistivity P-type single crystal rod; single crystal rod doped to your specifications — Dow Corning should lead your list of sources.




Write for "Hyper-Pure Silicon for Semiconductor Devices." Address Dept. 8216.

HYPER-PURE SILICON DIVISION
Address: HEMLOCK, MICHIGAN

**Dow Corning CORPORATION**

MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D.C.

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# Reduce Costly Kerf Losses

## in slicing semiconductor material...

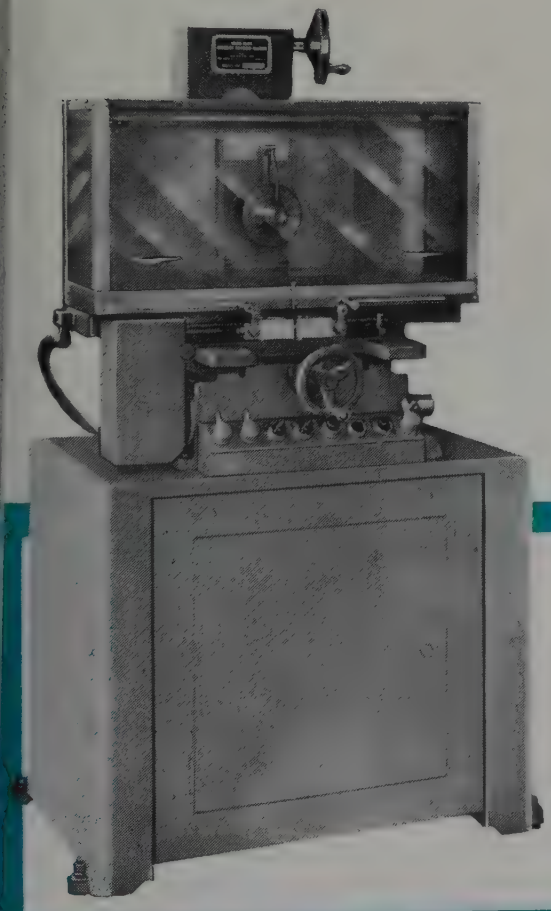
Now... switch to 3½" diameter diamond wheels to slice 1" diameter crystals on

**Micromech WAFERING MACHINES**

featuring the **NEW TYPE 2**

## CARTRIDGE SPINDLE

Micromech's newly-designed Type 2 Cartridge Spindle permits the use of thinner, smaller-diameter diamond wheels for slicing germanium and silicon. Provides top wafering efficiency with wheels of *all* sizes, too!



This specially-engineered spindle mounts a 3½" diamond wheel in place of the usual 5" wheel to give from 40% to 100% more slices per 1" diam. crystal . . . reduce kerf loss by 28% to 47%!

Micromech's 3½" diameter blades—in .010" thickness—can save from .004" to .009" per slice . . . add up to savings of $200.00 a day!

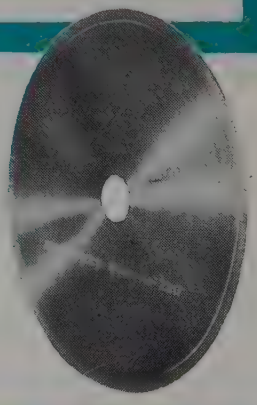
Moreover, the 3½" wheel allows cutting speeds up to 3" per minute . . . increasing production while decreasing loss of material.

Type 2 Cartridge Spindle is now standard on Micromech mechanical and hydraulic automatic wafering machines. Write today for detailed information.

## Micromech Diamond Wheels

Micromech stocks 3½" diamond wheels for the economical and fast slicing of all semiconductor materials.

Wheels also available in other popular and odd sizes, DIT and DITRS types. Precision manufacture to close tolerances assures accuracy of cut and long life.



**MICROMECH MANUFACTURING CORP.**

*A Division of Sanford Manufacturing Corp.*

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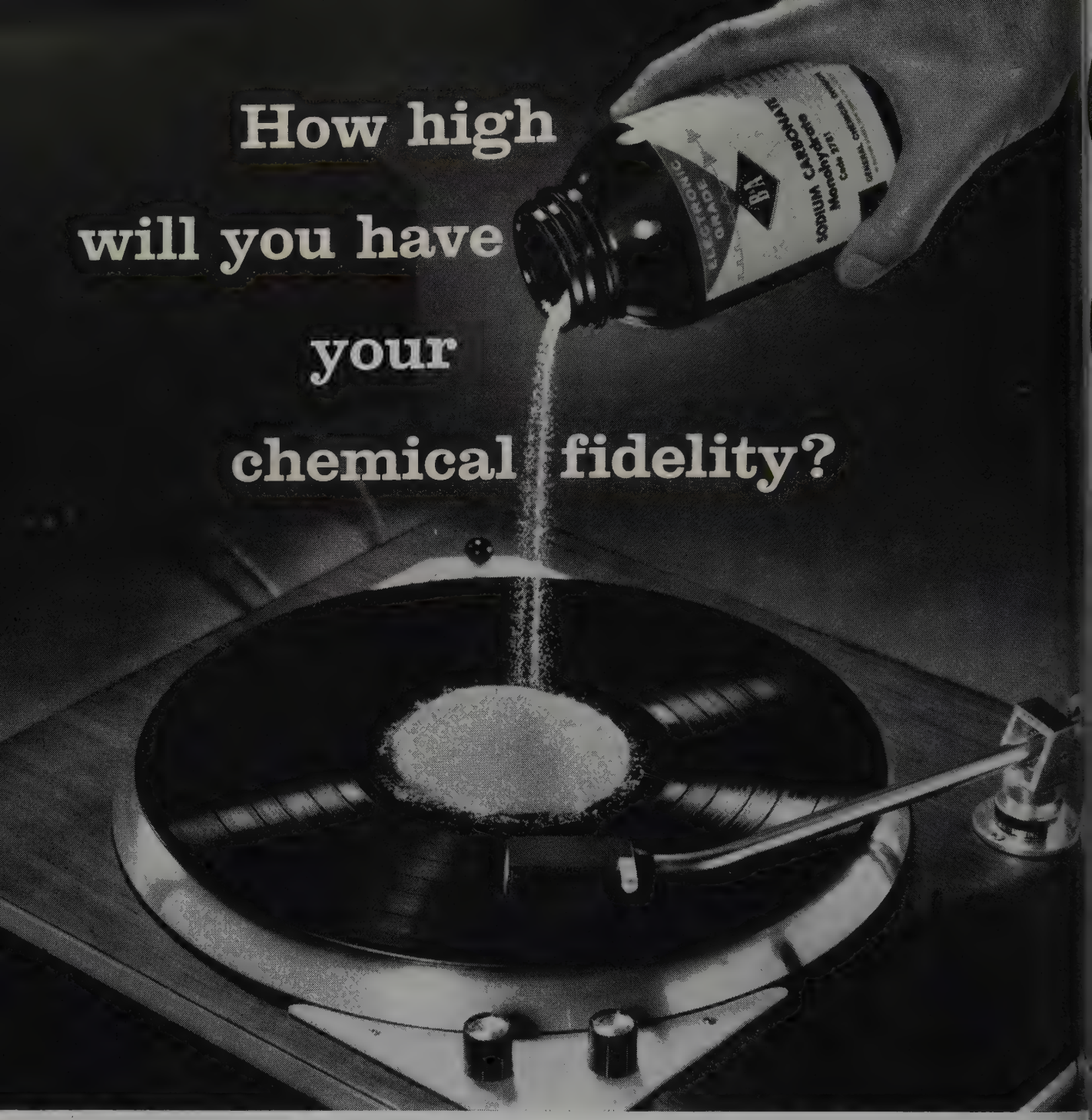


To be considered truly hi-fi, an amplifier's distortion at rated output should not exceed 1% at 20 CPS and 20,000 CPS. B&A® "Electronic-Grade" Chemicals meet standards far higher than these. Their maximum allowable impurities are limited to ten thousandths, even millionths of a *percent.*

These standards of purity are *pre-determined*—established by B&A quality control and development scientists to meet the electronic industry's rigid chemical requirements. In achieving these electronic-grade standards, Baker & Adamson consistently holds impurities at the lowest limits ever attained.

B&A has led the way in chemical purity since 1882. Today it is the largest supplier of high purity chemicals to the electronic industry. Our nation-wide network of shipping points provides same or next day delivery to most electronic centers. When specifying chemicals, rely on B&A to supply the finest . . . fastest.

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**"Electronic-Grade" Chemicals**

Allied Chemical

**GENERAL CHEMICAL DIVISION**
**40 Rector Street, New York 6, N.Y.**

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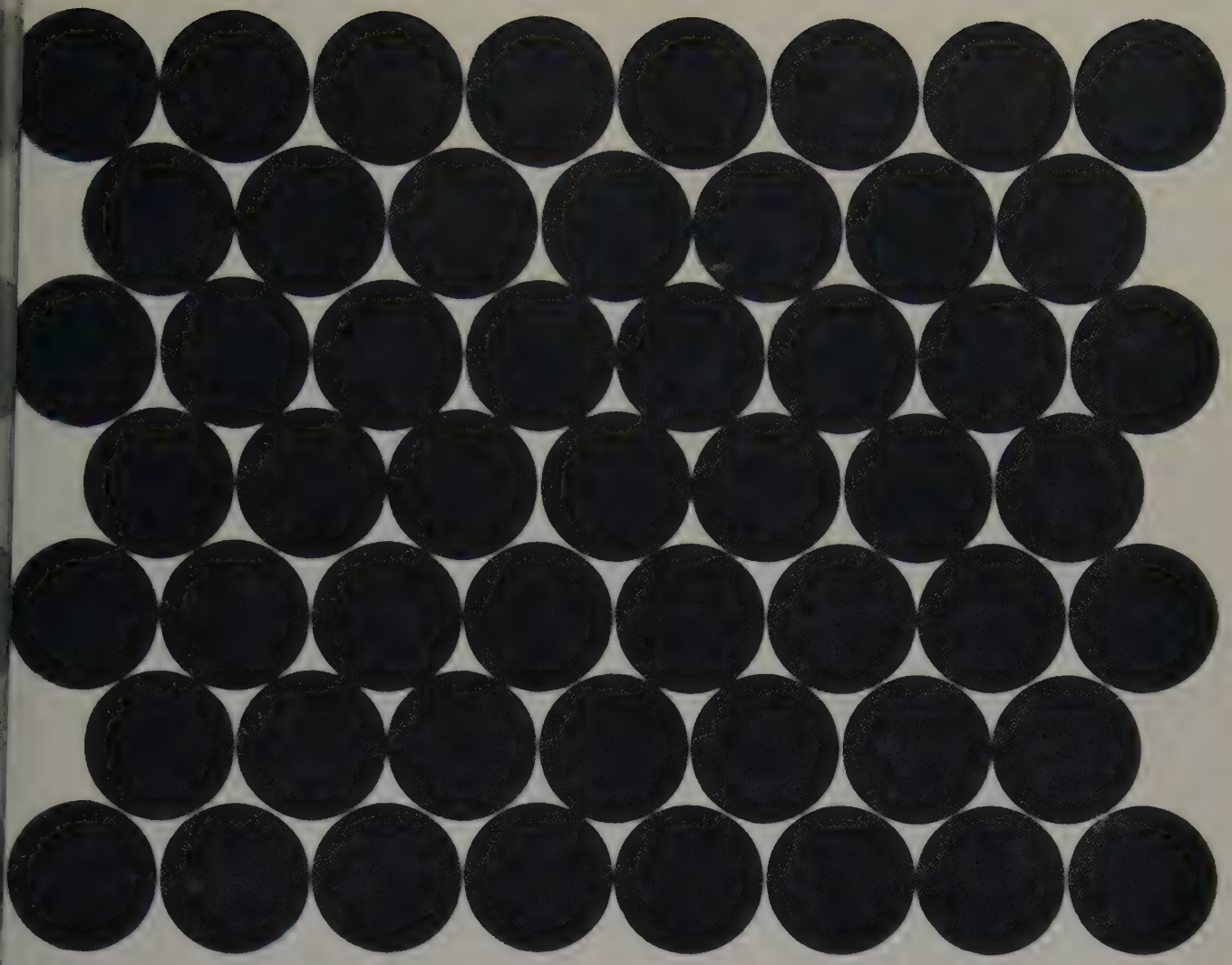

# GRACE UNIFORMITY...now in Silicon Slices and Lapped Slices to reduce your device manufacturing costs

Do-it-yourself crystal growing, slicing and lapping involves extensive expenditures in labor, space, and machinery. Besides tieing up your capital, you absorb the material losses. No wonder so many cost and quality-conscious device manufacturers are turning to Grace for slices and lapped slices . . . where they get 100% usable product to their exact specifications.

Another reason is *uniformity*. Grace ultra-high purity silicon in all forms is produced under standards far more exacting than even the most particular customer's specifications. This insistence on perfection assures you savings. You don't have to change your manufacturing process with each silicon order. Perfection is standard at Grace . . . where the quality control is constant from the basic chemistry to the delivered product.

Grace has all forms and grades of silicon. Call collect today for full details and price information. Even if you are doing your own slicing and lapping, you should have the facts on this valuable second source of supply.

**POLYCRYSTALLINE SILICON**—a) Bulk for Czochralski crystal growing. P or N type. Grades I, II, III and Solar. Large uniform lots.

b) Poly-Rods for zone refining. Diameters up to 1". Length to 15". Resistivity to 1,000 ohm-cm. with correspondingly high lifetimes.

**MONOCRYSTALS**—Czochralski and Float Zone monocrystals grown to *your* specifications.

**SLICES AND LAPPED SLICES**—Precise control assures uniform slice thickness, parallelism and surface perfection to your specifications.

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**GRACE ELECTRONIC CHEMICALS, INC.**

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# WE'VE INCREASED YOUR FLOOR SPACE!

Semimetals' new plant means greater capacity for you. Instead of expanding your own crystal-growing facilities, bring your requirements to us. We specialize in germanium monocrystals, zone-leveled or Czochralski, with standard or special dopants. All you do is specify resistivity, type, and dislocation density: we manufacture the crystals and deliver right on schedule. Standard germanium monocrystals in (111) orientation in 2-5,000/cm², 4-8,000/cm², or 6-12,000/cm² dislocation ranges. Other orientations or lower etch pit densities on special orders. And IR, too: lenses, windows, domes... cast or monocrystal. For prompt delivery, call or write us at our new address:

SEMIMETALS, INC.

172 Spruce Street • Westbury, L. I., N.Y. • EDgewood 3-8400

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## BIGGEST "LITTLE STOCK ROOM" IN THE SEMICONDUCTOR BUSINESS!

At Sylvania, *custom* parts by the million is customary.

Above you see a small part of our "stock room" in miniature. These are just some of the tiny parts we fabricate for the semiconductor industry and Sylvania is equipped to produce any metal part for device manufacturers.

With our millions-of-parts-per-day facilities we specialize in meeting tight specs and stringent production schedules. Parts produced from any of our 4-slide, press, small parts and eyelet equipment must all pass the exacting quality control requirements established for the semiconductor industry and at prices aimed at helping you hold down cost.

If you're looking for parts virtually "off the shelf"—header—emitter strap or wire base tab—connector or angle tab—cap or cup—internal spring lead or platform—clip or clamp—heat sink—cuts or leads, *specify Sylvania*. And if you need technical help with a difficult problem, our engineers stand ready to provide it. For full details, write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

# SYLVANIA

*Subsidiary of* **GENERAL TELEPHONE & ELECTRONICS**

GENERAL SYSTEM

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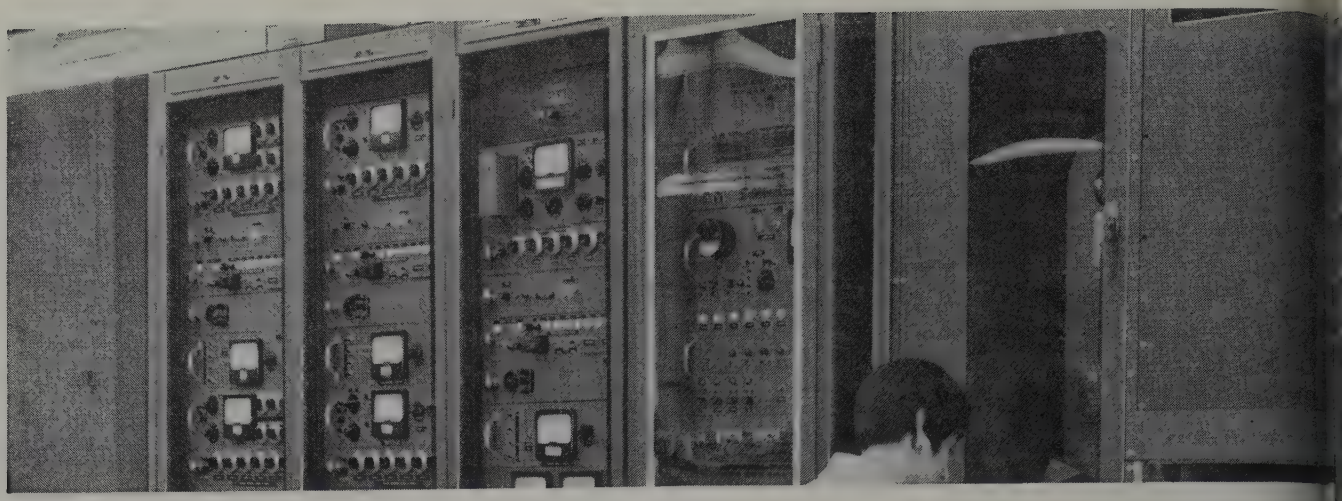
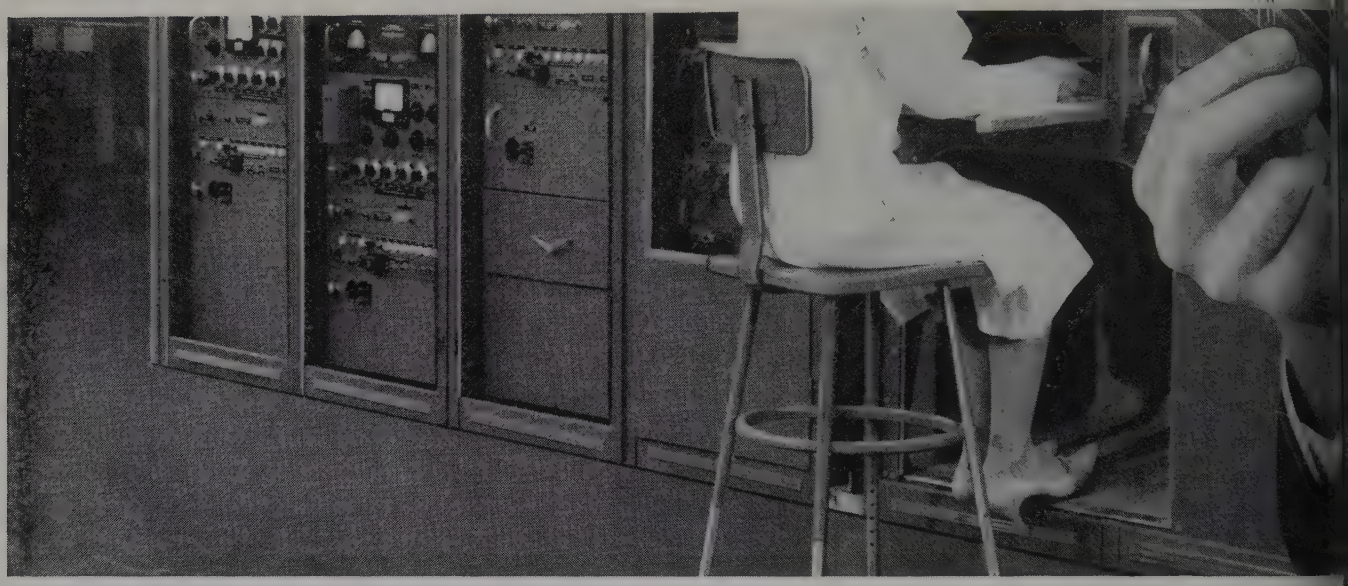
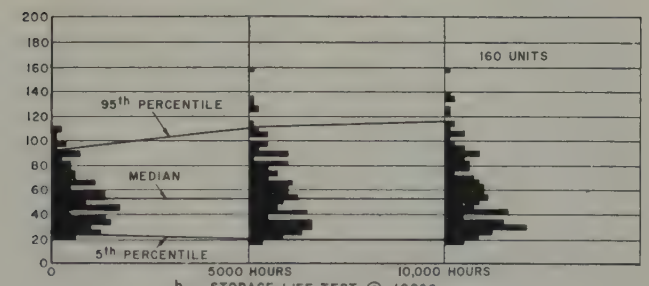


# The industry's most stable low-frequency PNP transistors!

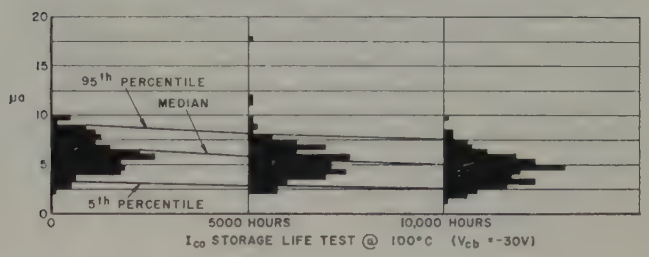


The man in the picture, Hugh Lowry, General Electric authority on semiconductor applications

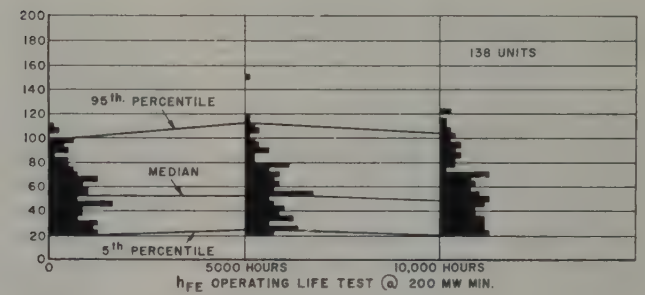
| TO-5 Type | Max. $V_{CBO}$ | Max. $V_{CER}$ | Max. $I_C$ | Max. $P_t$ | Max. Cutoff $I_{CO}$ @ $V_{CB}$ | 20 ma $h_{FE}$ Min. | 20 ma $h_{FE}$ Max. | $h_{FE}$ Min. | $h_{FE}$ Max. | $V_{CE}$ (SAT) | $V_{BE}$ | Max. $C_{OB}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2N524 | 45v | 30v | 500 ma | 225 mw | 10μa 30 | 19 | 42 | 16 | 41 | .070v | .255 | 40 |
| 2N525 | " | " | " | " | " " | 34 | 65 | 30 | 64 | .075v | .243 | " |
| 2N526 | " | " | " | " | " " | 53 | 90 | 44 | 88 | .080v | .230 | " |
| 2N527 | " | " | " | " | " " | 72 | 121 | 60 | 120 | .090v | .216 | " |
| 2N1413 | 35v | 25v | 200 ma | 200 mw | 12μa 30v | 25 | 42 | 20 | 41 | .070v | .255 | 40 |
| 2N1414 | " | " | " | " | " " | 34 | 65 | 30 | 64 | .075v | .243 | " |
| 2N1415 | " | " | " | " | " " | 53 | 90 | 44 | 88 | .080v | .230 | " |



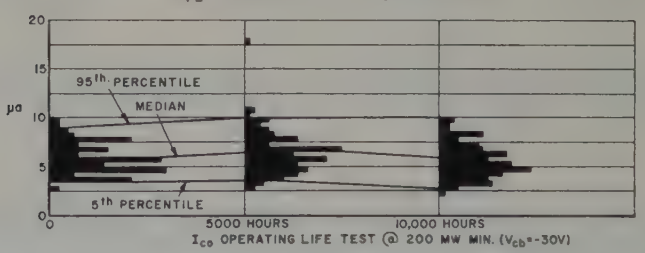
$h_{FE}$ STORAGE LIFE TEST @ 100°C



$I_{co}$ STORAGE LIFE TEST @ 100°C ($V_{cb}$ =-30V)



$h_{FE}$ OPERATING LIFE TEST @ 200 MW MIN.



$I_{co}$ OPERATING LIFE TEST @ 200 MW MIN. ($V_{cb}$=-30V)

# -eneral Electric 2N1414 and 2N525 Series carry omplete parameters backed up by 10,000-hour fe tests

You don't buy a "pig in a poke" when you standardize on General Electric low-frequency PNP germanium alloy transistors, Series 2N1414 and 2N525. Parameters are completely spelled out, including "Minimum," "Typical" and "Maximum" values, and are backed up by 10,000-hour life tests on 138 units to date (see curves above). In fact, 300 new units start life-test each week.

The new lower-priced 2N1413, 2N1414 and 2N1415 types are designed for industrial audio amplifiers and low-frequency switching applications where cost is a prime consideration.

To assure top reliability under adverse environments, all units are hermetically sealed and subjected to 100 hours of high-temperature bake and a detergent pressure leak test. The transistor base is welded to the case for greater thermal efficiency.

For proved reliability in low-frequency PNP's, at a very pleasant price, see your G-E Semiconductor District Sales Manager or Authorized Distributor. General Electric Company, Semiconductor Products Department, Electronics Park, Syracuse, N. Y. *In Canada:* 189 Dufferin St., Toronto, Ont. *Export:* International General Electric Co., 150 E. 42nd St., N. Y. C.

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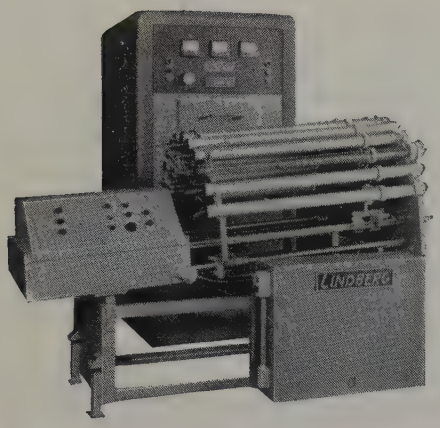
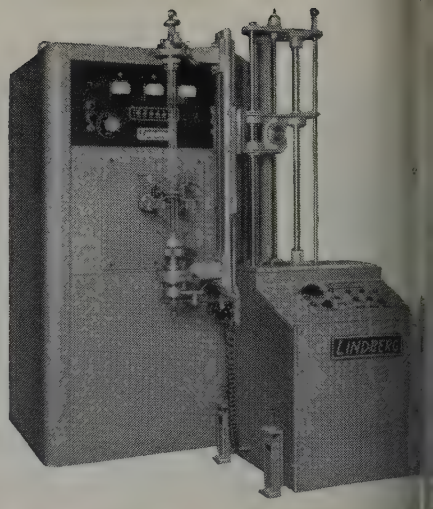
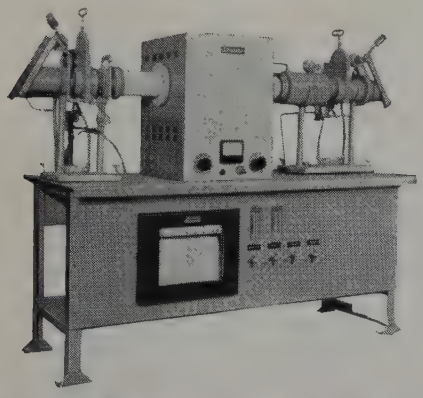



Horizontal Zone Scanner for zone purification of metallic germanium and other metallic and organic materials.

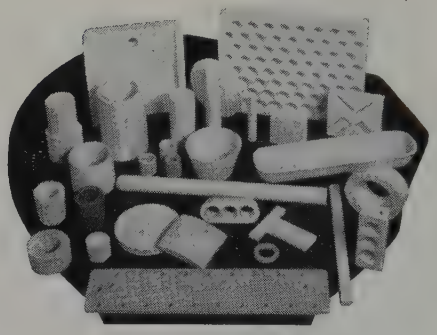
Low Temperature Furnace for solar cells and treatment of metals.



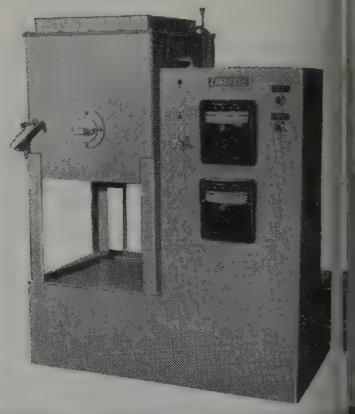

Vertical Floating Zone Scanner for accura and precise production of hyper-pure sem conductor materials and metals.



Batch Type Atmosphere Furnace for low temperature alloying.



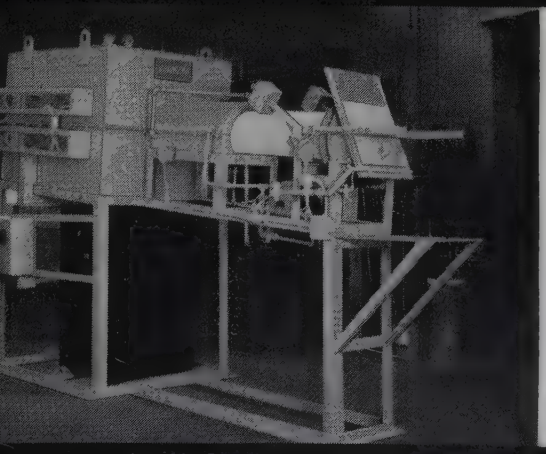
We can engineer and produce refractory designs and mixes—dishes, boats, crucibles of zircon, zirconia, alumina, pure oxides, etc., for specific needs.



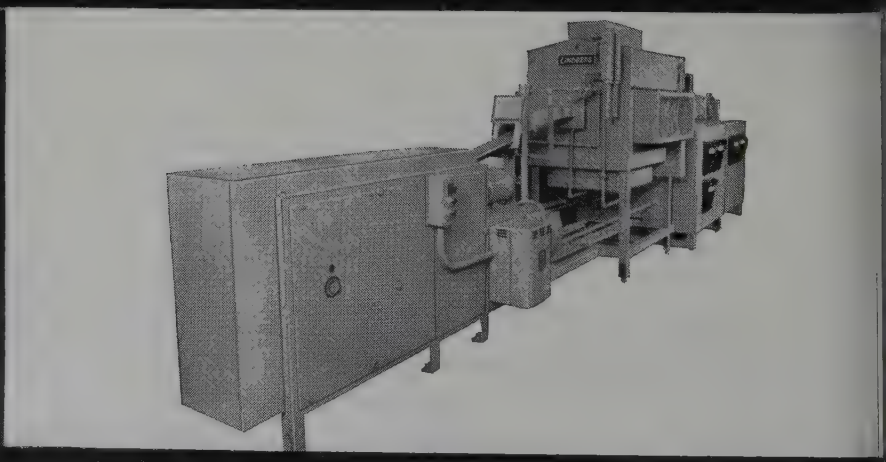
High Temperature Crucible Pe Furnace for melting. Maximu temperature 1600°C.

# for Semiconductors

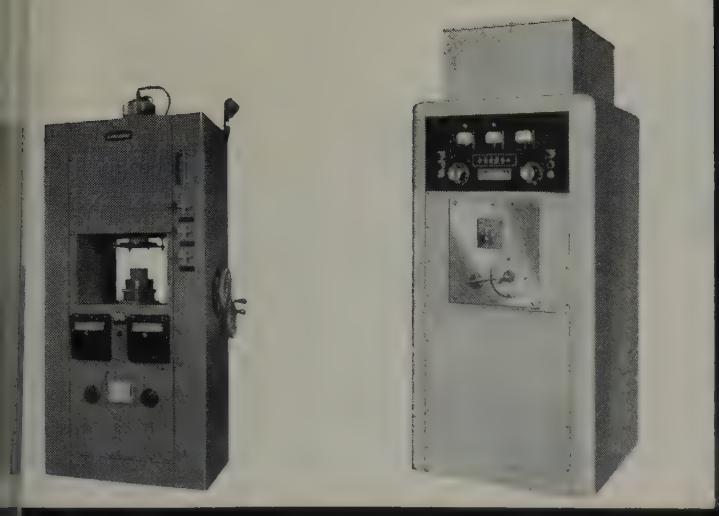
Lindberg n comprehens



Hydrogen Atmosphere Furnace for reduction of germanium oxides and other materials.



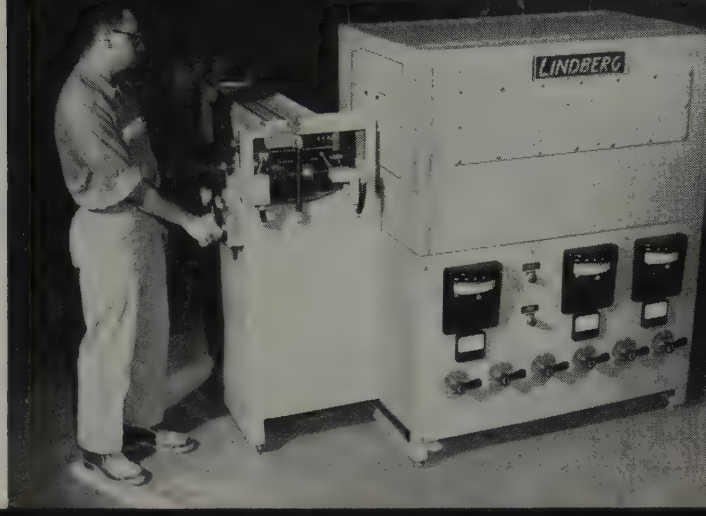
Hump Type Mesh Belt Conveyor Furnace for precision alloying of transistors and diodes.



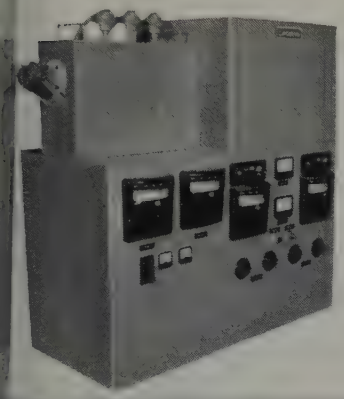
gh Temperature Tube Furce for germanium ingots.



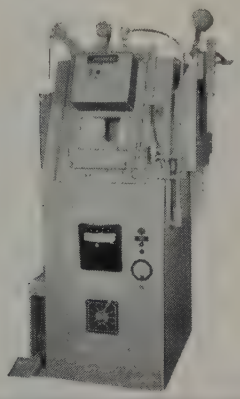
Dual frequency unit for zone refining, one of a complete line of induction heating units.



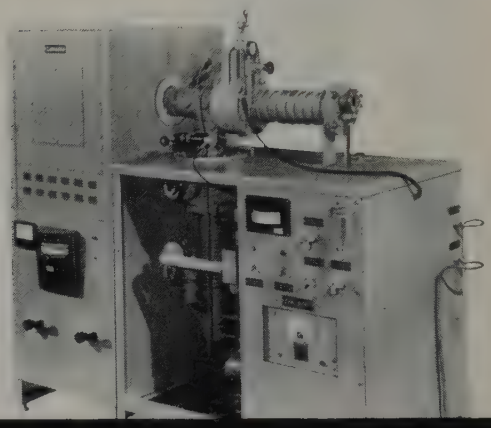

Mechanical Pusher Type Furnace for production of transistors by gas diffusion.



ecision Gas Diffusion Furnace with ultiple controls for quality transistor d semiconductor bodies.



High Temperature Gas-Tight Box Furnace for solar cells.



Vacuum unit for gas diffusion in alloy muffle or refractory.

# ers the most advanced designs, the most e, in efficient, precise, production equipment.

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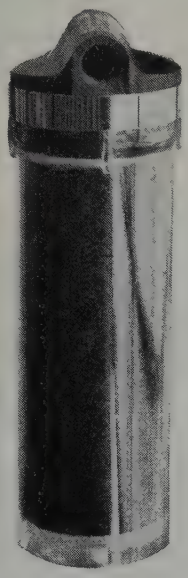

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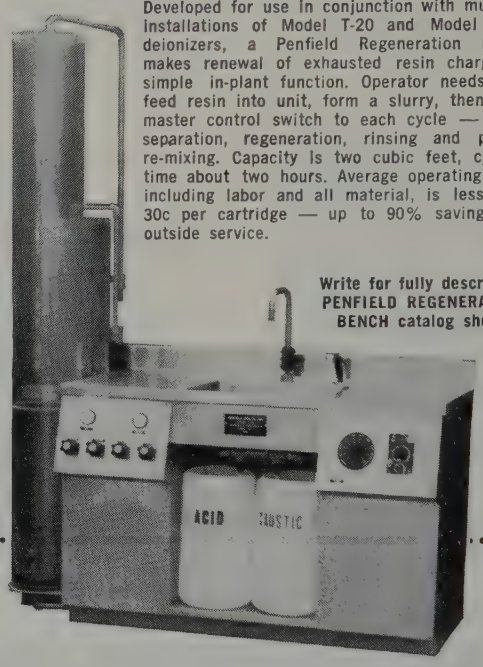


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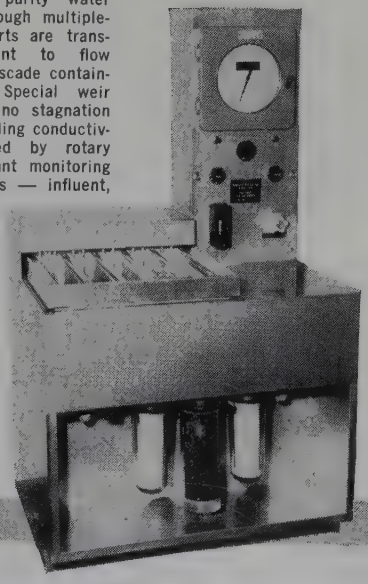

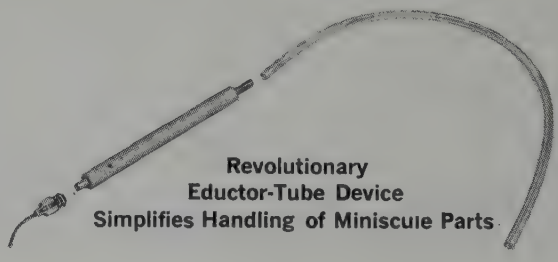

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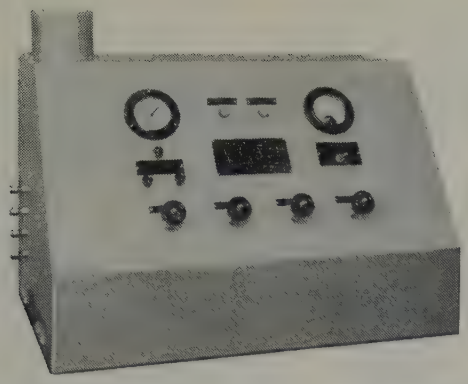

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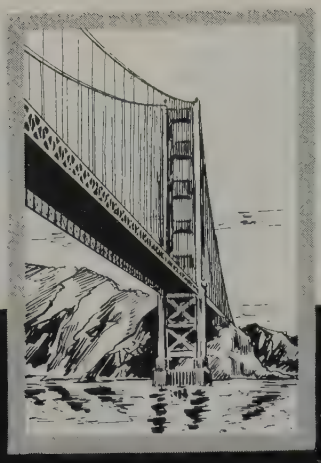

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# MEET

# 0-8

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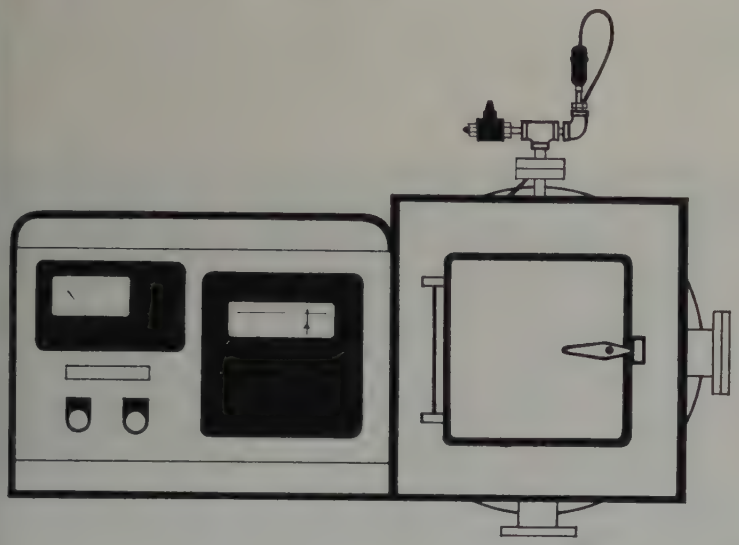

Here is Tri Metal's low-cost 0-8 oven engineers throughout the nation are talking about. This unique model consists of a suspended inner muffle surrounded by heating elements mounted on ceramic stand-off insulators. The heating elements are surrounded by a series of polished shields which reflect the radiated heat onto the muffle and thus achieve exceptional temperature uniformity. The outer shell of the oven is water cooled. No water cooling of the door is required. The low-cost Neoprene door gasket remains cool even when the oven is operating continuously at elevated temperatures.
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Low-Cost, Neoprene "O" ring gaskets guaranteed one year.

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**What prompted engineers at Western Electric's** Laureldale, Pa. plant to use an Alpha gold alloy preform? What made them think it would successfully join their silicon device to the molybdenum base?

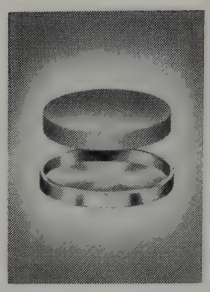
Simply this:

Gold wets silicon and molybdenum well. Antimony insures the device's retention of its n-type characteristics. The preform Alpha fabricated to Western Electric specifications contains both gold and antimony.

This Alpha *Goldcup* meets Western Electric requirements in other ways, too:

1. **It is made from foil** just .0005" thin.
2. **It is cup-shaped** and kept to extremely close tolerances; walls fit snugly against the molybdenum base, assuring positive wetting.
3. **It is available** in production quantities.

Western Electric is typical of the many successful diode and transistor producers who use Alpha gold alloy preforms as a high temperature solder. They employ *Goldcups* for attaching wafer to base tab or for making electrical contact between leads and studs.



Alpha Goldcup and molybdenum disc before fusion. Illustration 15 times actual size.

Alpha specializes in formed parts of gold and gold alloys in a variety of shapes: spheres, washers and discs. Typical of the precision and miniaturization of Alpha *Goldforms* are washers with an .020" i.d. and a land of .005"

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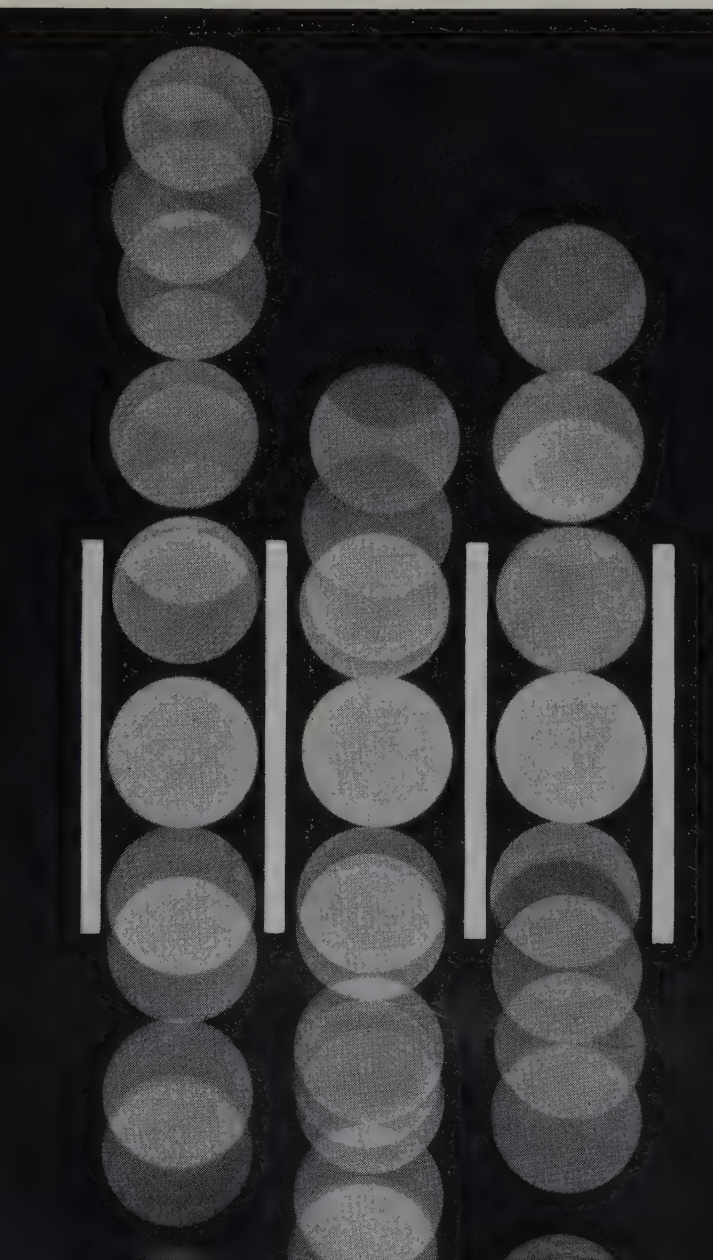
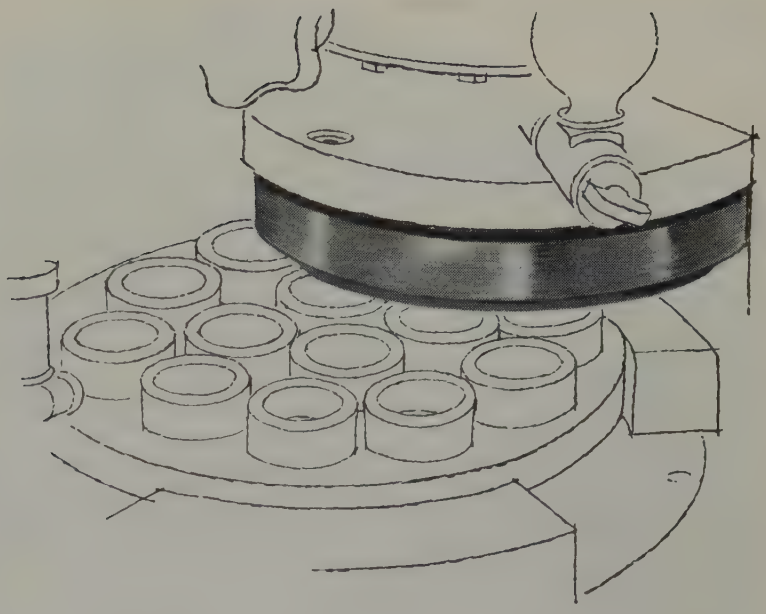


## Making Metals Behave...

**Western Electric bonds hard-to-join molybdenum base into silicon device with Alpha Goldcups**



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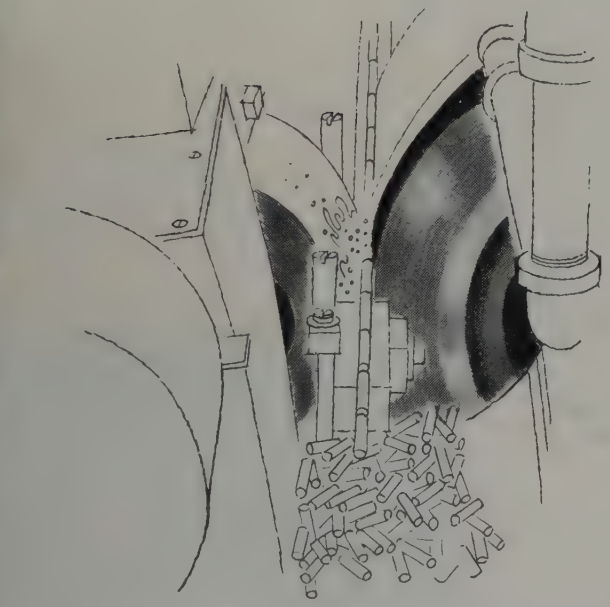

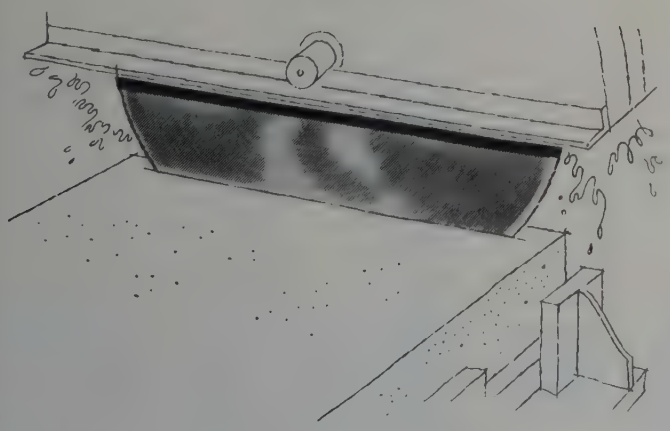

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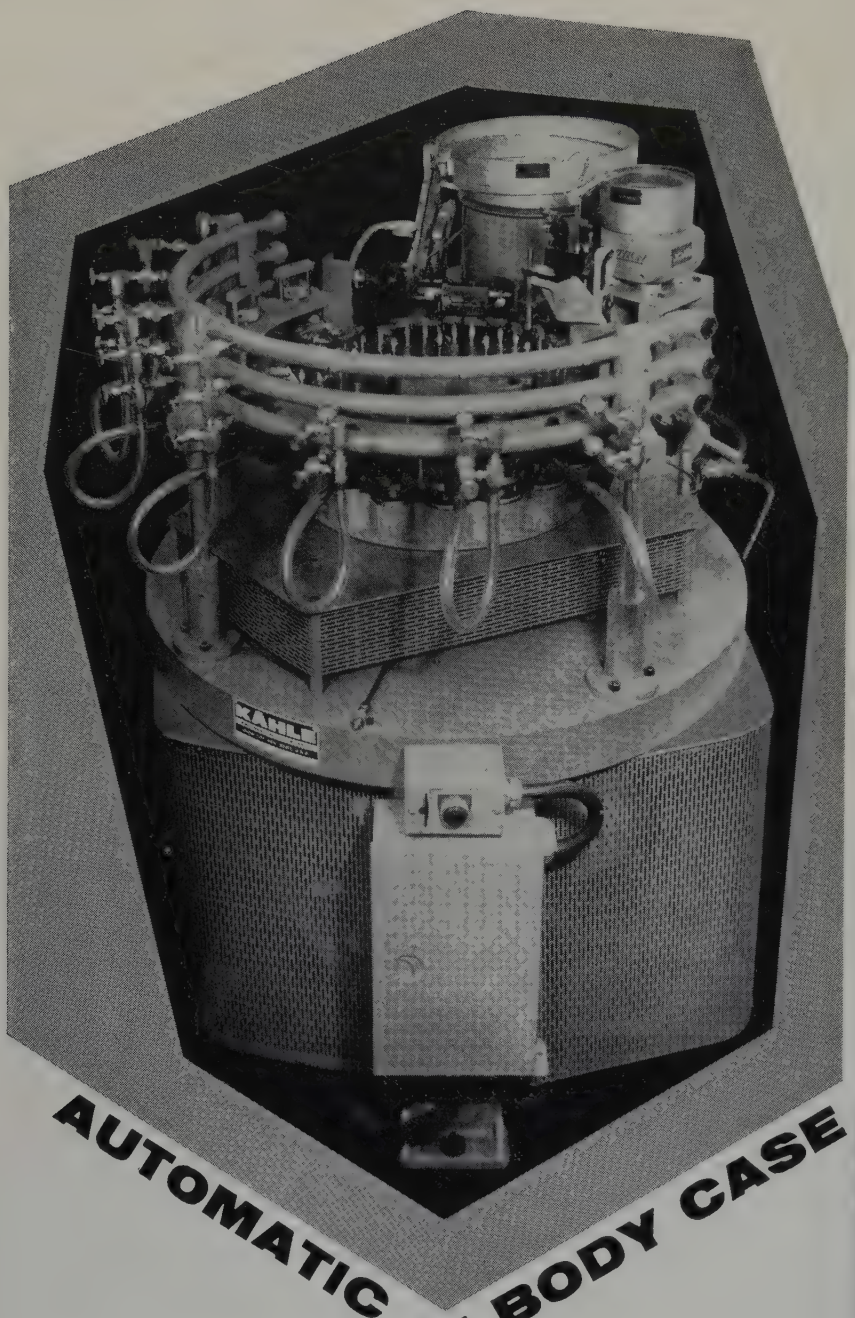

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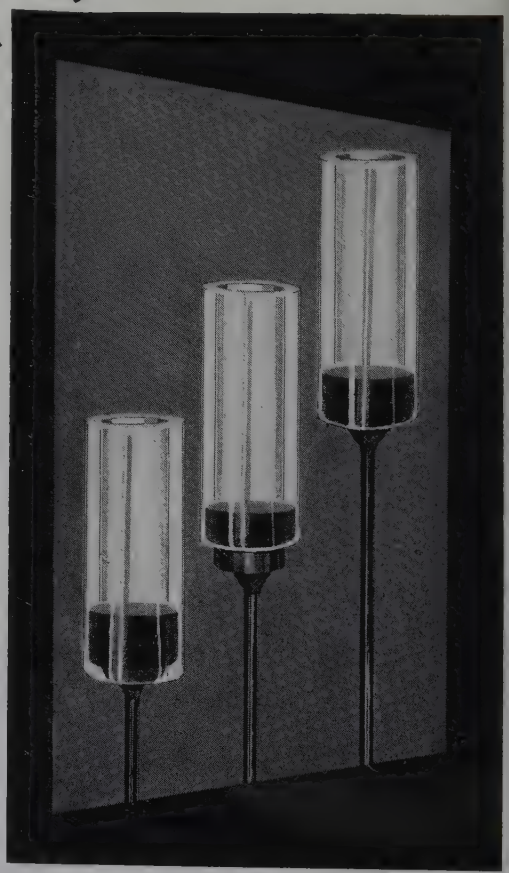

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# Editorial . . .

## Tunnel Diode Progress

The recent International Solid State Circuits Conference has brought to the fore the state of the art in tunnel diode circuitry along with other interesting topics in thin film techniques, ferrite memories, etc.

The diode is characterized by its cutoff frequency $\omega_c$, its resonant frequency $\omega_r$ and its junction time constant $\tau$. Specifying as $g$ the tunneling conductance, $C$ the junction capacitance and $R_s$ and $L$ the series resistance and inductance, they are related to $\omega_c$ and $\omega_r$ as follows:

$$\omega_c = \frac{g}{C}\sqrt{\frac{1}{gR_s}}$$

$$\omega_r = \frac{g}{C}\sqrt{\frac{C}{Lg^2} - 1}$$

$$\tau = \frac{C}{g}$$

Since the voltage characteristic depends only on the semiconductor nature, the output power may be increased only by an increase of the peak current, i.e., by an increase of the junction area. This corresponds to increases of $C$ and $g$, where the values of $C/g$ and $gR_s$ remain approximately constant. Hence $\omega_c$ remains approximately constant, but $\omega_r$ decreases.

Series compensation of $L$ permits a modification of $\omega_r$. Gallium arsenide diodes have favorable electrical characteristics, but the present technology of formation gives junctions which degrade with aging. For instance, if zinc dopant is used it is found that the peak current decreases while the valley current remains constant. On the other hand, if cadmium dopant is used the opposite behavior is noted. This deterioration may be due to a vacancy mechanism, and is accompanied by an increase of the junction capacitance.

Aside from the above mentioned instability, gallium arsenide diodes have been used successfully in stripline and cavity structures to provide oscillators to 103 kMc and amplifiers to 23 kMc. For example, a 7.5 kMc, 0.5 mw oscillator was operated for about three months continuously before decaying. An 11 kMc amplifier with 20 db gain, 20 Mc bandwidth presented a noise figure of 11.5 db. A simpler structure, involving a coaxial line with a series connected tunnel diode provided a video amplifier with about 400 Mc bandwidth at a 6 db gain.

The tunnel diode may also be used in circuits operating in the parametric mode, i.e., with a mode described by means of a linear variable differential equation. A simple $L$-C-$G$ parallel circuit, where $G$ is provided by the tunnel diode, may be operated as a down converter with appropriate pump frequency. As an example, a down converter with a pump frequency of 7 kMc, a signal frequency of 1.4 kMc, a gain 20 db and a bandwidth of 200 Mc has been described. These circuits however do not present advantages with respect to the simpler straightforward negative conductance amplifiers.

A very important application of tunnel diodes appears to be in the field of logic circuits. Various circuits suggested to date require close tolerance of the components and are further limited by the bidirectional nature of the diode. Circuits utilizing the tunnel diode in the voltage mode and using rectifiers for the transfer of information were described. These may be operated either synchronously (with an auxiliary clock) or asynchronously, and appear exempt from the above limitations. As an example, a synchronous OR circuit which required a clock signal of 500 mv with a tolerance of $\pm$ 250 mv, and which provided unidirectional routing of the information, was described.

# NEW BELL LABORATORIES RESEARCH FORESHADOWS COMMUNICATIONS AT OPTICAL FREQUENCIES

A revolutionary new device, the continuously operating Optical Gas Maser, now under investigation at Bell Telephone Laboratories, foreshadows a whole new medium for communications: light.

Light waves vibrate at frequencies tens of millions of times higher than broadcast radio waves. Because of these high frequencies, a beam of light has exciting potentialities for handling enormous amounts of information.

Now for the first time, Bell Laboratories' new Optical Gas Maser continuously generates light waves that are "coherent." That is, the light waves move in phase as seen looking across the beam.

With further research, it is expected that such beams can be made to carry large amounts of information. The beams can be transmitted through long pipes. They can be projected very precisely through space, and might be used for communications between space vehicles.

Research with coherent light is another example of how Bell Laboratories prepares ahead for communications needs.

The Optical Gas Maser (above) was first demonstrated at Bell Telephone Laboratories. Heart of unit is a 40-inch tube containing helium and neon. Interaction between gas atoms produces a continuous, coherent beam of infrared light that may one day be used in communications.

BELL TELEPHONE LABORATORIES

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# High-Speed Logic Using Low-Cost Mesa Transistors

D. GIPP* R. D. LOHMAN* R. R. PAINTER* B. ZUK*

**This article discusses the use of the 2N1301 mesa switching transistor in digital logic circuits. Two systems are described (*RCTL* and *RTL*) and performance data for both systems are presented. The operation of a serial adder constructed from the basic building blocks is also described.**

THE 2N1301 IS A SINGLE-DIFFUSED drift-field germanium mesa transistor having a gain-bandwidth product ($F_T$) of approximately 50 megacycles. The 2N1301 is characterized in general by high power-dissipation capabilities, high gain over a wide range of collector current, mechanical ruggedness, and low charge storage in saturation. Some of the more pertinent characteristics used in the design of switching circuits are summarized in Table I and *Fig. 1*.

**TABLE I**

**Electrical Characteristics of 2N1301 Mesa Transistor**

| | |
|---|---|
| **Maximum Voltage Ratings:** | |
| $V_{CB}$ | 13 Volts |
| $V_{CE}$ | 12 Volts |
| $V_{EB}$ | 4 Volts |
| **Maximum Power Ratings:** | |
| at 25°C | 150 *mw* |
| at 55°C | 75 *mw* |
| **Minimum Current Transfer Ratio:** | |
| at $I_C = 10$ *ma* | 30 |
| at $I_C = 40$ *ma* | 40 |
| **Maximum Stored Charge:** | |
| at $I_C = 10$ *ma* | 375 μμC |
| at $I_C = 40$ *ma* | 800 μμC |
| **Minimum Gain Bandwidth:** | |
| at $I_C = 10$ *ma* | 35 Mc |

## RCTL Systems

*Figure 2* shows the general arrangement employed in *RCTL* (resistance-capacitance-transistor-logic) systems. For an *N*-input gate, *N* transistors are connected with their collectors in parallel. The circuit is designed so that a negative voltage of $V_{CL}$ volts at any one of the *N* inputs causes the corresponding transistor to saturate and reduces the output voltage at a common collector node to zero. If, on the other hand, all the inputs are at zero volts, all *N* transistors are *off* and the collector voltage is clamped at $V_{CL}$ volts by the diode $D_1$. The collector voltage then becomes a

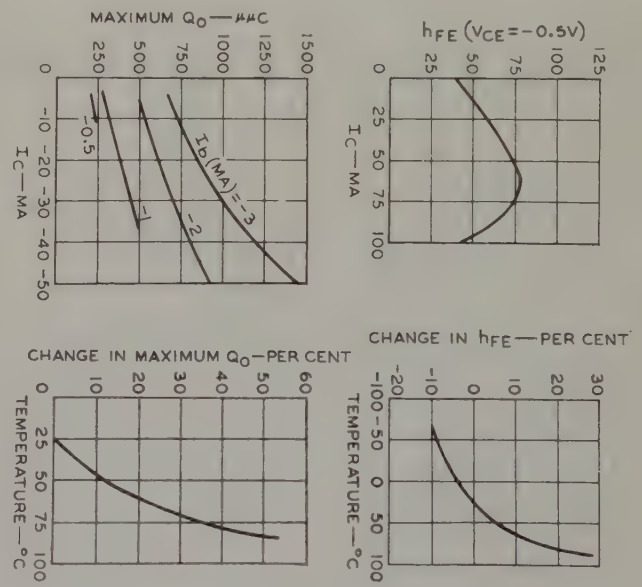


**Fig. 1—Electrical characteristics of 2N1301 mesa transistor.**

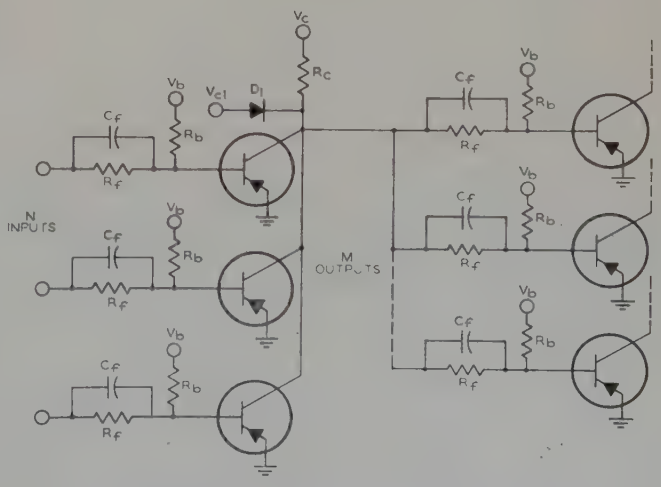


**Fig. 2—Generalized *RCTL* circuit.**

*Radio Corporation of America
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Somerville, N.J.

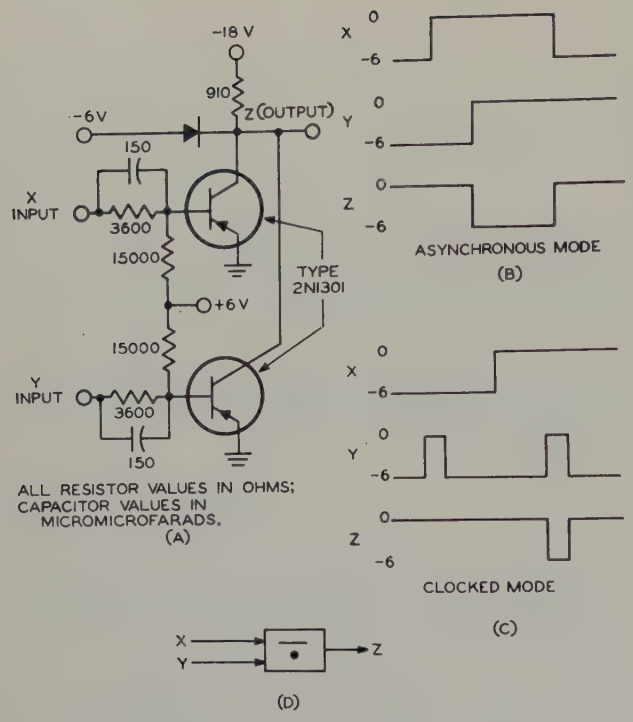


**Fig. 3—Diagram and waveforms for *RCTL nand* gate.**

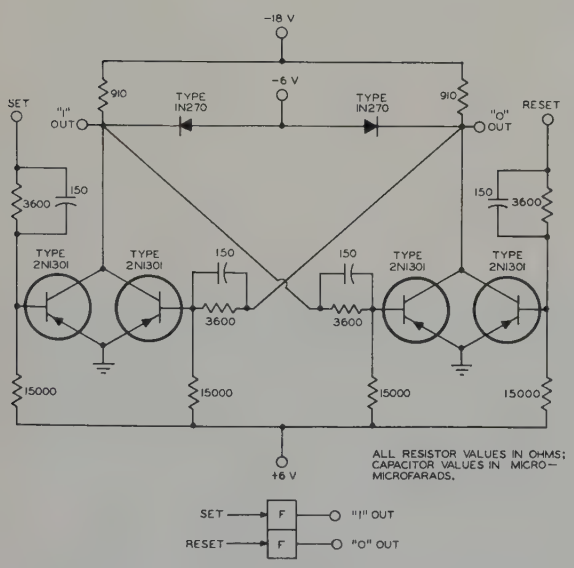


**Fig. 4—*RCTL* flip-flop arrangement**

source for *M* other inputs. The capacitors in parallel with the input resistors are used to compensate for the charge stored in an *on* transistor and, when properly chosen, make *RCTL* circuits extremely fast. The detailed design procedure for this type of gate is given in Appendix I.

A two-input circuit capable of driving five other inputs (i.e., a fan-in of two, fan-out of five) is shown in *Fig. 3a*. The operation of this circuit is illustrated by the waveforms of *Figs. 3b* and *3c*. In *Fig. 3b*, both inputs are *d-c* voltage levels of either zero or —6 volts.

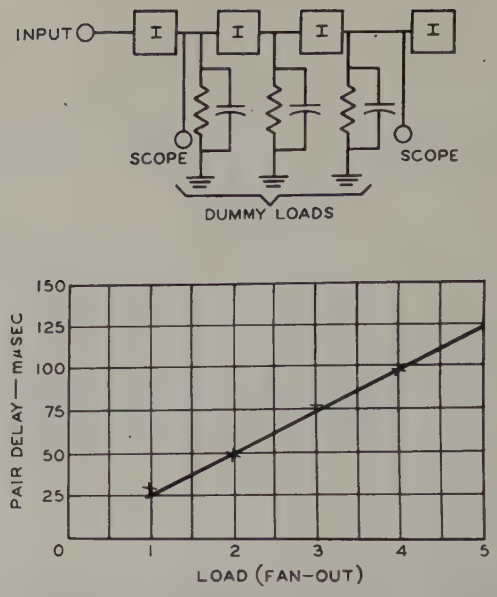


**Fig. 5—"Pair delay" of *RCTL* system as a function of fan-out loading.**

The output is —6 volts only when both inputs are zero volts. If binary "1" is assigned the value of zero volts, while binary "0" is assigned the value of —6 volts, the circuit performs the logical function *not and*, or *nand*. In *Fig. 3c*, one of the inputs is a positive pulse referenced at —6 volts. This pulse appears at the output of the gate only if the level input is 0 volts. In this case, the pulse is also inverted. The level input can thus control the transmission of the pulse. The gate is suitable, therefore, for use in either an asynchronous or a clocked mode. *Fig. 3d* shows the symbolic representation of the *nand* gate.

A *set-reset* flip-flop may be formed by the interconnection of two gates, as shown in *Fig. 4*. The flip-flop is set and reset by negative-going pulses which constitute the output of the basic gate when used in the clocked mode. If the "1" output is used as the level input to a gate, the gate passes a clock pulse when the flip-flop is in the "1" state and inhibits the clock pulse when the flip-flop is in the "0" state. This combination of compatible gates and flip-flops can be used to synthesize a wide variety of logical systems.

To determine the maximum speed with which information can be processed through such a system, it is necessary to know the propagation delay of signals passing through several gates in series. The "pair delay" is defined as the delay that a signal undergoes when it passes through two gates in series under fixed conditions of loading. "Pair delay" is used rather than "stage delay" so that the two signals will be of the same polarity and shape. *Fig. 5* shows the measured pair delay for the *RCTL* gate of *Fig. 3* as a function of fan-out loading. The logical speed which can be obtained with a system using such a gate can be predicted from this curve. In summary, *RCTL* systems are characterized by a relatively large number of transistors and extremely fast operation.

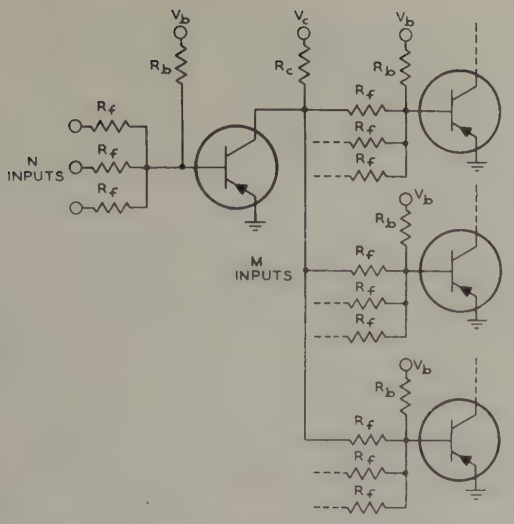


**Fig. 6—Generalized *RTL* circuit.**

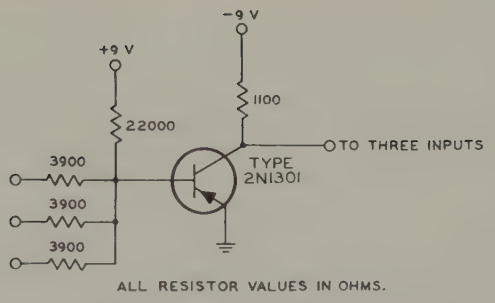


**Fig. 7—*RTL nand* circuit.**

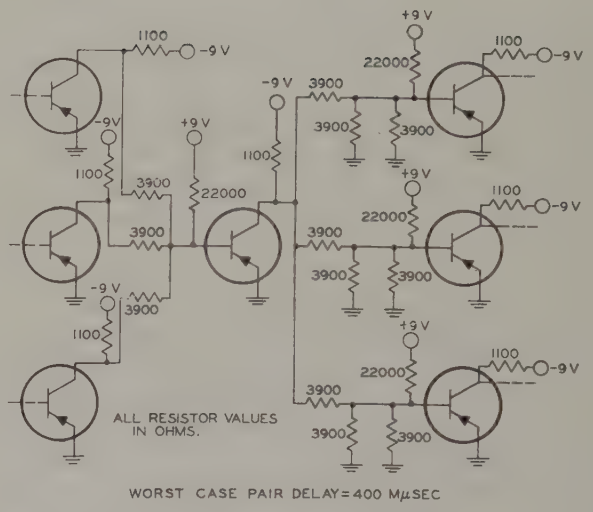


**Fig. 8—Pair delay of *RTL* circuit under "worst-case" conditions.**

## RTL Systems

The general *RTL* (resistance-transistor-logic) circuit is shown in *Fig. 6*. The logic performed by this arrangement is identical to that performed by the *RCTL* circuit. Asynchronous or clocked operation can be used, and flip-flops are formed in the same way. The design equations for the general *RTL* circuit are given in Appendix II.

An *RTL* gate having three inputs capable of driving three inputs (fan-in of 3, fan-out of 3) is shown in *Fig. 7*. Pair delay for *RTL* is not a simple function of fan-out, as it is for *RCTL*.

*Fig. 8* illustrates the "worst-case" conditions for pair delay for the *RTL* circuit of *Fig. 7*. Worst-case pair delay occurs in *RTL* when alternate stages are subjected to maximum drive conditions, then minimum, then maximum, and so on. Maximum drive produces short rise but long storage and fall times, whereas minimum drive produces long rise but short storage and fall times. Maximum drive occurs when a given stage is driven by three other unloaded stages. Minimum drive occurs when a given stage is driven at one input by a fully loaded stage. These conditions are illustrated in *Fig. 8*. Calculation of *RTL* delays other than that of the "worst case" is beyond the scope of this paper.

## Binary Serial Adder

The application of these building blocks to a high-speed serial adder is illustrated in *Fig. 9*. Information is read into the adder and out of the carry storage by clock 1 pulses. Information is read out of the adder and into the carry storage by clock 2 pulses which are interleaved between clock 1 pulses. Thus, the first clock 1 pulse shifts the two least significant digits of the two numbers to be added into the adder. At this time, the output of the carry storage is zero. The next clock 2 pulse reads the sum term for these two digits out of the adder and stores the carry if one was gen-

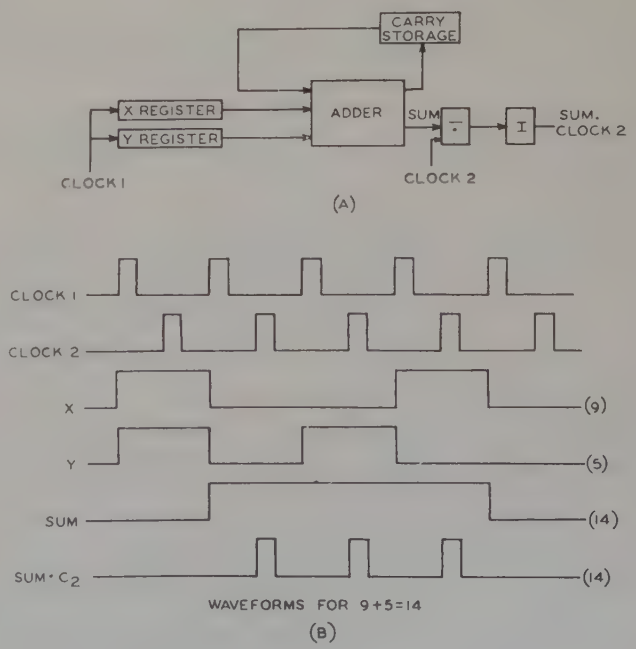


**Fig. 9—Diagram and waveforms for serial adder.**

erated. The next clock 1 pulse then shifts into the adder the next two digits to be added and at the same time reads out the previous carry if there was one. The operation continues until all digits of both numbers have been read into the adder. One additional clock 1 pulse and clock 2 pulse then complete the operation.

*Figure 10* shows in block form how the adder and carry storage are implemented by the basic *nand* gates described previously.

For further study of the operation of the adder, a number generator consisting of the outputs of a two-stage counter was built. The numbers and the sum output are repetitive, and waveforms can be photographed throughout the system. *Fig. 11* shows the operation of the *RCTL* adder at a clock rate of 2.5 megacycles. The adder and number generator, which together use sixty 2N1301 transistors, have achieved 4000 hours of continuous running time at an ambient temperature of 65°C without failure.

In *Fig. 12,* the same waveforms are shown for the *RTL* adder at a clock rate of 500 kilocycles.

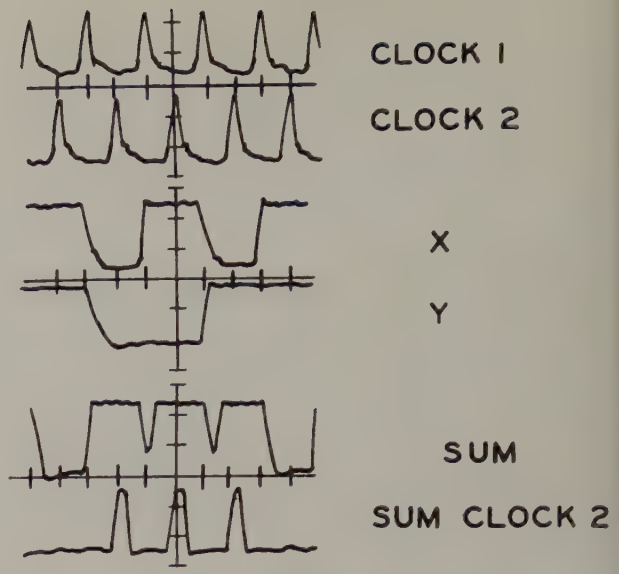


**Fig. 11—Waveforms for *RCTL* adder.**

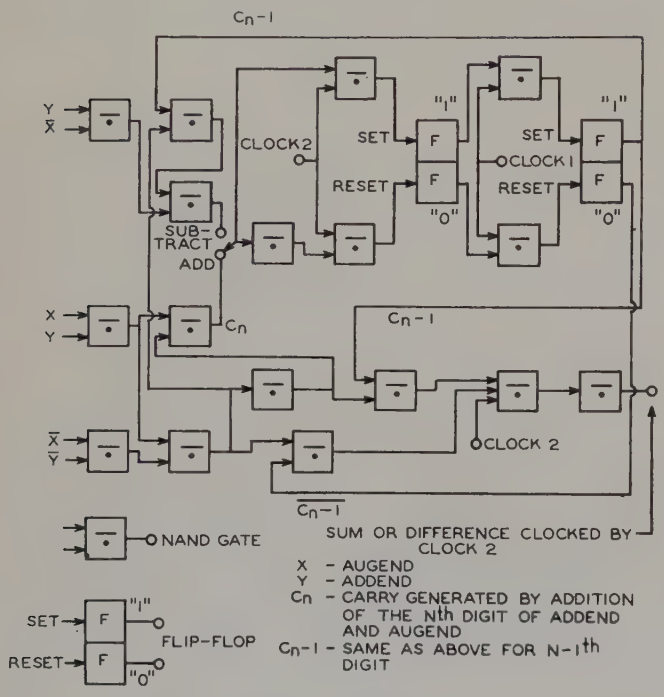


**Fig. 10—Block diagram of high-speed serial adder.**

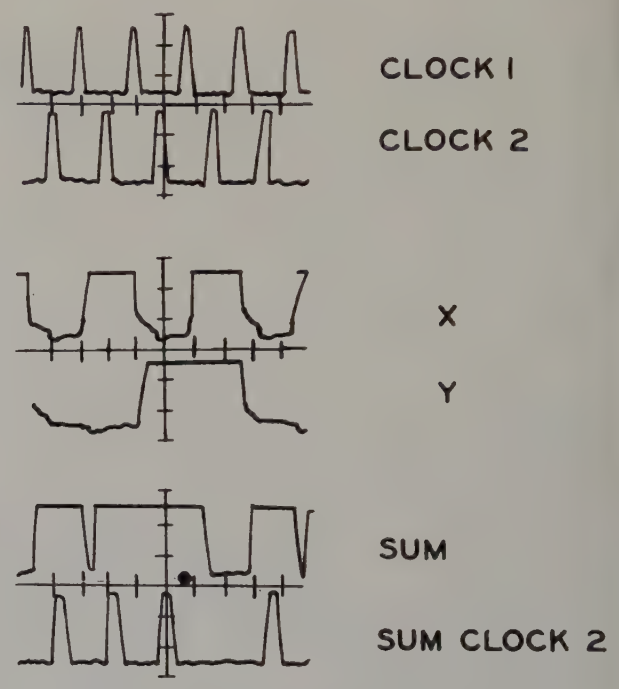


**Fig. 12—Waveforms for *RTL* adder.**

## Appendix I.

If a satisfactory solution is to be obtained for the system shown in *Fig. 2* under *d-c* or static conditions, the following conditions must be met even in the worst case:

(a) an *off* transistor must have its base reverse-biased by $V_0$ volts,

(b) an *on* transistor must have sufficient base drive to "bottom" it, and

(c) the current in the clamp diode must never be less than zero. These conditions are specified more precisely by the following equations:

$$\frac{\underline{V_b} - \left[\overline{I_{B0}}\,\overline{R_b} + \overline{V_{CE}}\,\overline{\frac{R_b}{R_f}}\right]}{1 + \overline{\frac{R_b}{R_f}}} \geq V_0 \qquad (1)$$

$$\frac{\underline{V_{CL}} - \overline{V_{be}}}{\overline{R_f}} - \frac{(\overline{V_b} + \overline{V_{be}})}{\underline{R_b}} \geq \frac{\overline{V_c}}{\underline{R_c}\,\underline{\beta}} \qquad (2)$$

$$\frac{\underline{V_C} - \overline{V_{CL}}}{\overline{R_c}} - N\overline{I_{CO}} - \frac{M\,(\overline{V_{CL}} - \underline{V_{be}})}{\underline{R_f}} \geq 0 \qquad (3)$$

where $\overline{X}$ = maximum value of $X$
$\underline{X}$ = minimum value of $X$
$V_C, V_{CL}, V_b$ = supply voltages
$R_f$ = base resistor
$R_c$ = collector resistor
$R_b$ = "hold-off" resistor
$\beta$ = current transfer ratio of the transistor at a collector current of approximately $V_C/R_C$.
$V_{CE}$ = collector saturation voltage of transistor for $I_C = V_C/R_C$ and $I_B = V_C/R_C\beta$
$V_{BE}$ = base saturation voltage for $I_C = V_C/R_C$ and $I_B = V_C/R_C\beta$
$I_{CO}$ = collector leakage current
$I_{bo}$ = base leakage current
$N$ = fan-in
$M$ = fan-out

When the circuit has been designed for *d-c* stability, the capacitor value may be selected as follows:

(a) solution of the circuit for the maximum values of base current and collector current,

(b) determination (from the curves of *Fig. 1*) of the maximum stored charge for this base and collector current at the maximum temperature of interest, and

(c) selection of $C$ to satisfy $C = Q_{o\ max}/V_{CL}$.

### Appendix II.

The solution of the system shown in *Fig. 6* is similar to that described in Appendix I for the *RCTL* case. The corresponding equations are:

Definition of terms is the same as for the *RCTL* case.

$$\frac{\underline{V_C}}{\underline{\beta}\,\underline{R_C}} \leq \frac{(\underline{V_C} - \overline{I_{CO}}\,\overline{R_C} - \overline{V_{be}})\,\underline{R_f} - (M-1)\,\overline{R_C}\,(\overline{V_{be}} - \underline{V_{be}})}{\underline{R_f}\,\overline{R_f} + (M-1)\,\overline{R_C}\,\overline{R_f} + \overline{R_C}\,\underline{R_f}} - \frac{(N-1)\,(\overline{V_{be}} - \underline{V_{CE}})}{\underline{R_f}} - \frac{(\overline{V_b} + \overline{V_{be}})}{\underline{R_b}} \qquad (4)$$

$$\overline{I_{bo}} \leq \frac{\underline{V_b}}{\overline{R_b}} - N\frac{\overline{V_{CE}}}{\underline{R_f}} \qquad (5)$$

# A Low-Drift Direct-Coupled Transistor Amplifier For High Temperature Applications

JAMES W. HALLIGAN*

**A direct-coupled transistor amplifier circuit which is suitable for high temperature applications is described. This circuit has an advantage in that no external temperature-sensitive element is required to provide compensation for the variation of $I_{co}$ with temperature. An experimental amplifier which satisfied the derived conditions for thermal stability was designed and constructed. The amplifier exhibited no drift over the temperature range from +25°C to +125°C.**

IN DESIGNING a direct-coupled transistor amplifier, one of the primary considerations is the *d-c* stability of the amplifier at high temperatures. The usual solution to this problem is to include in the amplifier an external temperature-sensitive device to provide compensation for the variation of collector-base reverse saturation and leakage current ($I_{CO}$) with temperature.

The circuit presented here is unique in that no external temperature-sensitive device is required. The amplifier may be adjusted for zero *d-c* drift over a wide temperature range, while maintaining considerable gain.

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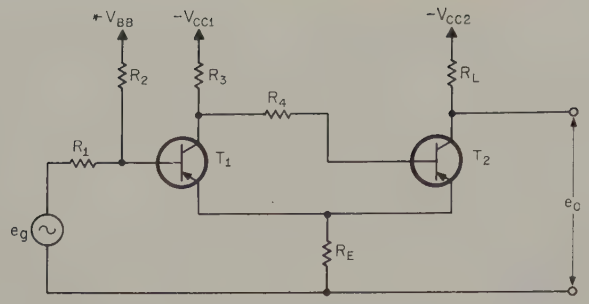


**Fig. 1—Direct coupled amplifier.**

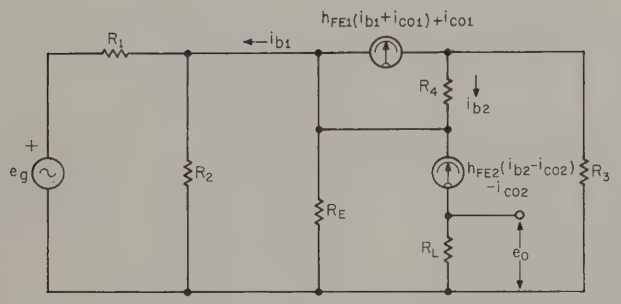


**Fig. 2—Approximate equivalent circuit of the direct coupled amplifier.**

### Amplifier Description

*Figure 1* shows a direct-coupled amplifier using two transistors. The emitters are connected to a common emitter resistor. This has the effect of eliminating the degeneration which normally results from an unbypassed emitter resistance. Degeneration is effectively eliminated because the *a-c* signals through this resistor from each transistor are 180° out of phase. The emitter resistor also provides compensation for the variation of $I_{CO}$ with temperature.

In general terms, the amplifier provides the required compensation for the $I_{CO}$ variation in the following manner.

With an increase in temperature, the collector current of the first stage ($T_1$) increases by $i_{CO1}(h_{FE1}+1)$, where $h_{FE1}$ is the *d-c* short-circuit common-emitter current gain of $T_1$ and $i_{CO1}$ is the increase in the $I_{CO}$ of $T_1$. This is the case because the ratio $\frac{R_1R_2/R_1+R_2}{R_E} > h_{FE1}$. The resistors $R_3$ and $R_4$ provide a division of this current increase such that approximately $(h_{FE})$ $(i_{CO1})$ $(R_3/R_4)$ is applied to the base of the second transistor $(T_2)$. The collector current of $T_2$, therefore, increases by approximately $h_{FE2}$ $(i_{CO2} - \frac{h_{FE1}\, i_{CO1}\, R_3}{R_4})$, where $i_{CO2}$ is the increase in the $I_{CO}$ of $T_2$ with temperature. To eliminate *d-c* drift in the output of $T_2$, it is necessary to adjust the ratio $R_3/R_4$ so that the proper current division occurs to make $i_{CO2} = (h_{FE1})$ $(i_{CO1})$ $(R_3/R_4)$. Thus, the $I_{CO}$ variation of the first transistor is used to provide the necessary compensation to the second transistor, and no external temperature-sensitive element is required in the amplifier.

### Analysis of the Amplifier Circuit

*Figure 2* shows an approximate equivalent circuit for the direct-coupled amplifier. This equivalent circuit may be solved for the output voltage, $e_o$. The solution is

$$e_0 = \frac{h_{FE1}\, h_{FE2}\, R_L}{R_1\left(1+\frac{R_4}{R_3}\right)} e_g + h_{FE2} R_L \left[ i_{CO2} - \frac{(h_{FE1}+1)\, i_{CO1}}{\left(1+\frac{R_4}{R_3}\right)} \right] - i_{CO2} R_L \quad (1)$$

provided that the condition

$$R_3 = \frac{R_1 R_2}{h_{FE1}(R_1+R_2)} \quad (2)$$

is met. This relation determines the value of $R_3$.

Generally, the last term on the right is negligibly small for silicon transistors. In order to make $e_o$ independent of $i_{CO}$, the second term on the right is made zero by adjusting $R_4$ such that

$$\frac{i_{CO1}}{i_{CO2}} = \frac{h_{FE1}+1}{\frac{R_4}{R_3}+1}. \quad (3)$$

It should be noted that either $i_{CO1}$ or $i_{CO2}$ may be the greater quantity, but Eq. (3) requires that they be within a factor of $(h_{FE}+1)$ of each other in magnitude. This is the case because $1 \leqslant (1+\frac{R_4}{R_3}) < \infty$, and therefore, $0 < \frac{i_{CO1}}{i_{CO2}} \leqslant (h_{FE1}+1)$. If $i_{CO1} = i_{CO2}$, then $R_4 = h_{FE1}\, R_3$, and the voltage gain of the amplifier becomes

$$\frac{e_0}{e_g} = \frac{h_{FE2}\, R_L}{R_1}. \quad (4)$$

### Experimental Results

*Figure 3* shows the component values of an experimental amplifier which was constructed. Resistors $R_2$ and $R_4$ were experimentally adjusted to give a *d-c* output level of −3.0 volts at +25°C and at +125°C. Note that Eq. (2) is not satisfied by the actual values used in the circuit.

The transistors only were temperature-cycled from +25°C to +125°C; the *d-c* output level remained constant at −3.0 volts over this temperature range. The *a-c* voltage gain, defined here as the change in output voltage per unit change in the base voltage of $T_1$, was measured at 40 *cps* over the temperature

range of +25°C to +125°C. *Fig. 4* shows the variation in *a-c* voltage gain to be approximately 0.06 *db* per degree Centigrade.

The emitter resistor ($R_E$) does not appear in Eq. (1) and normally would not be required in the amplifier. However, Eq. (1) holds only if the condition of Eq. (2) is satisfied. If Eq. (2) is not satisfied, $R_E$ appears in the expression for $e_o$, and serves to provide additional compensation for both the $I_{CO}$ and $h_{FE}$ variations with temperature. In addition, the presence of $R_E$ makes the adjustment of the bias resistor ($R_2$) less critical.

The condition of Eq. (2) can not be satisfied over a range of temperature with fixed-value components, since $h_{FE1}$ is a function of temperature. If $R_3$ is a temperature-sensitive device which varies inversely with $h_{FE1}$, the *d-c* output drift will be exactly compensated, and no emitter resistance is necessary. However, the gain will vary as $h_{FE2}$ with temperature. A more practical circuit results if $R_3$ is a fixed value resistor which satisfies Eq. (2) at room temperature only, and an emitter resistance is included in the amplifier. The *d-c* drift, due to $I_{CO}$ variation, is still negligible because of the presence of $R_E$, while the gain varies approximately as $h_{FE2}\ (1 + \Delta h_{FE1})$, where $\Delta h_{FE1}$ is the increase in $h_{FE1}$ caused by increased temperature. This is a reasonable compromise between gain stability and *d-c* drift.

The amplifier was adjusted experimentally to obtain the best temperature stability consistent with a reasonable gain, and the experimental values were measured. These component values were found to be generally in agreement with the calculated values. The use of the equivalent circuit for the analysis thus seems justified.

### Conclusion

No *d-c* drift was observed in the output of the experimental amplifier over the temperature range of +25°C to +125°C. As shown in *Fig. 4*, the *a-c* voltage gain was observed to increase from 27.2 *db* at +25°C to 33.5 *db* at +125°C, an increase of approximately 0.06 *db* per degree Centigrade.

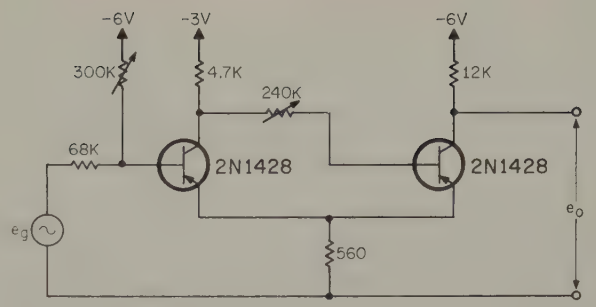


**Fig. 3—Experimental direct coupled amplifier.**

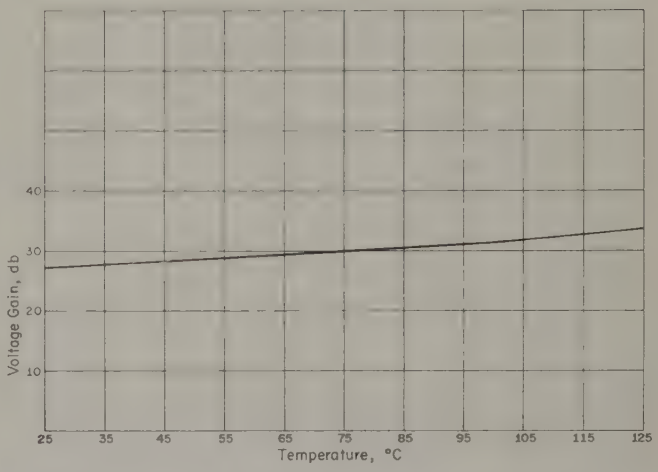


**Fig. 4—Variation in a-c voltage gain with temperature.**

Two bias supplies were required in the experimental amplifier. This is the case because $R_3$ is small compared to $R_L$, yet each transistor should have approximately the same operating point. Since the emitter voltage is developed across a common emitter resistor, the collector supply voltage is necessarily smaller for the transistor with the smaller load resistor.

The experimental results show the excellent degree of compensation obtained with this circuit over a wide range of temperature.

# Vacuum Float Zone Refining of Silicon

FRANK BOURASSA*

Float zone refining, once considered a hopeless commercial process, has become practical by virtue of the introduction of various innovations to the basic technique. Among these innovations have been the application of automation, the use of ultra-high vacuum, a method for controlling crystal diameters, and the development of doping during the refining process.

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### Ultra-High Vacuum

High vacuum in the production of ultra-pure silicon

is an effective and economical technique for processes requiring inert atmosphere. Although the units are equally adaptable to inert gas, the routine use of vacuum is felt justified since vacuum conditions are innately purer than any inert gas, and considerably cheaper.

The equipment used produces a vacuum of $10^{-5}$ mm. of mercury. This operating pressure is equivalent to inert gas with an impurity ratio of one part in 100 million. Vacuum is drawn by a 13 cu. ft./min. roughing pump, operating through a 6 in. water-cooled oil diffusion baffle.

This extremely low operating pressure is lower than the vapor pressure of arsenic, antimony, and aluminum. These, along with many other crucial impurities, are removed from the silicon by evaporation.

This is particularly significant in regard to phosphorus, which next to boron, is the most difficult impurity to remove. Its evaporation is accelerated when float zone refining is conducted under high vacuum.

### Design and Operation

The equipment for vacuum and for automation is an integral part of the design of these float zone refining units. Each unit consists of a vacuum chamber resting on top of the "control desk," which envelops the vacuum pump below. Electrical equipment is housed in a cabinet beside each unit. Once in operation, the units run automatically through float zone refining cycles which regularly last several hours. Polycrystalline rods up to 1 in. in diameter and up to 2 ft. long, produced in a separate process, are used as raw material for the zone refining process.

The operator mounts the rod vertically in the vacuum chamber in a special metallic chuck. In line with the rod at the bottom end of the chamber is another chuck into which is mounted an oriented single crystal seed. The water cooled chamber is pumped down to a vacuum of at least $10^{-4}$ mm. of mercury.

The power to the induction work coil surrounding the rod is furnished by an *rf* generator operating at a frequency of about 4 megacycles. The work coil is positioned near the upper chuck. The silicon itself resists *rf* coupling due to its high resistivity, but as it absorbs heat from the metallic chuck, its resistivity decreases until the coil couples-in directly with the silicon.

Kept at an incandescent state (600-800°C.), the heated zone is lowered to the bottom end of the rod. The power is then increased and a molten boule is formed on the lower, free end of the rod. The seed is then introduced into the molten silicon. With the seed bonded-in; the automatic controls take over.

As the floating molten zone moves up the rod with the coil, impurities are either volatilized or transported with the molten section. At the end of the "pass," the molten zone is stretched to prevent the freezing silicon from expanding into the coil. The power is then reduced automatically to hold the zone incandescent until the coil returns to the seed end to begin the next pass.

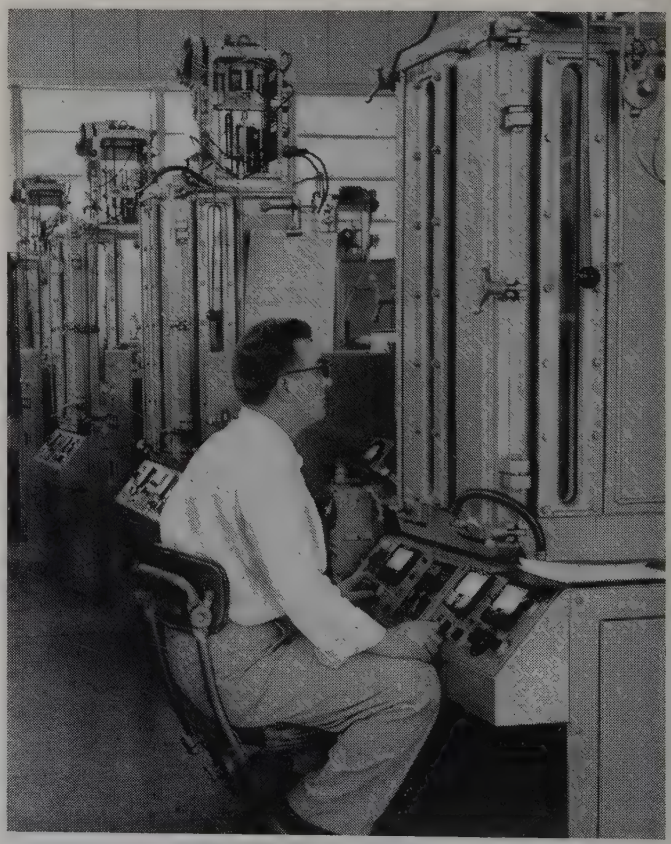
To attain the standard resistivity of 1000 ohm-cm that is routinely produced, requires several passes. By additional passes, however, silicon with resistivities well in excess of 1000 ohm-cm can be produced.

### Purity

Vacuum zone refining eliminates impurities which drastically affect the minority carrier lifetime of the crystal. According to Merck, such purity cannot be achieved by the Czochralski method, since boron and oxygen are absorbed by the silicon from the quartz crucible. With float zone refining there is no contact with containers of any kind. Prior to float zone refining, the boron content of the silicon is brought down to less than 1 atom in 6 billion by the Siemens reduction process, which yields polycrystalline rods ready for zone refining without "casting."

Another consideration presented refers to the oxygen content in Czochralski-grown silicon crystals. It has been shown that these crystals contain up to $10^{18}$ oxygen atoms per cc. of silicon.

Oxygen does not drastically affect resistivity measurements in the manner that boron and other impurities do. However, under the thermal cycles used in device fabrication, resistivity can change due to the presence of oxygen atoms. The resistivity of float zone refined crystals is more stable under the thermal



**Automatic Vacuum Zone Refiners in Operation.**

cycles used in device fabrication. This is an important factor for increasing device yields.

### Diameter Control

Float zone refining is especially applicable to silicon because its high surface tension and low density help support the "floating zone" and prevent the molten silicon from running off. Additional support for the molten zone is obtained from the levitation forces of the electromagnetic field by positioning the induction coil closely around the silicon rod. Standard single crystals with diameters in excess of 23 mm are being routinely produced.

With automatic power control the crystal diameter is regulated so that variation is less than 0.5 mm. over the entire length of the rod. Feedback circuits increase or decrease power to the work coil as required to maintain a constant coil voltage. As an additional means of diameter control, axial traverse of the chuck is also provided for. Orientation of the seed in the chuck controls orientation of the single crystal. The standard (111) crystal is produced.

### Doping

The basic float zone refining technique has been developed so that the silicon can be doped with desired donor or acceptor impurities at the same time that undesirable impurities are being removed. By extremely critical calculation of the amount of dopant, the number of passes and speed of the passes, the dopant level can be controlled. Moreover, the dopant is uniformly segregated throughout the silicon while it is crystallized. By this technique, boron doped *p*-type and phosphorus doped *n*-type single crystals in standard resistivities ranging from 0.1 to 300 ohm-cm are produced. The base boron content of the doped crystals corresponds to the uncompensated minimum of the 1000 ohm-cm *p*-type crystals.

### Custom-Control

An important characteristic of the technology is its flexibility. The same controls which yield maximum uniformity of product are adaptable to produce almost any variation in specifications. This flexibility also applies to the product. Its basic purity has eliminated guesswork in doping and has put production of semiconductor materials on a scientific basis.

# A Graphical Design Procedure for Transistor Resistor Logic Stages

THOMAS L. FRANCIS*

**Logical *nor* stages (Transistor Resistor Logic) must be designed to meet d.c. circuit considerations imposed by the logic, and a.c. transient requirements imposed by timing and operating speed. Designing for both conditions would require an extremely complicated analysis and computer solution. The approach presented here is a graphical d.c. design that allows transient optimization through bench testing to be performed on logically correct circuits. Bench modifications and the d.c. design can be satisfied with a minimum amount of analytical manipulation by graphical means.**

UNDER CERTAIN ASSUMPTIONS, a graphical approach to the design of transistor-resistor-logic stages can be made that offers a rapid design procedure and controlled propagation time. Assume as a design case that,

(a) One of $N_i$ inputs is to go *on*
(b) All of $N_0$ outputs are fully loaded
(c) Output swing is set by a clamp diode
(d) Minimum transistor beta is used
(e) No tolerances on components or supply voltages

Making these assumptions, the *d-c* equations for the TRL stage can be written in a simple form. Because there are no tolerances or parameter limits, these equations can be solved simultaneously and be presented as a simple set of graphs for determining resistance values, fan-in, and fan-out.

Consider the following *pnp* circuit, shown in *Fig. 1.*

For the input circuit, the following equations can be written:

*Central Research Laboratories, Texas Instruments Incorporated, Dallas, Texas.

$$I_{RT} = I_b + I_{bf} + I_{off} \quad (1)^{\dagger}$$

$$I_{off} = \frac{(V_{be} - V_{ce})\,(N_i - 1)}{R_T} \quad (2)$$

$$R_T = \frac{V_{in} - V_{be}}{I_{RT}} \quad (3)$$

For a fan-in of one and the transistor driven to the edge of saturation,

$$R_{T1} = \frac{V_{in} - V_{be}}{I_b + I_{bf}} \quad (4)$$

From Eq. 3 we get:

$$R_T = \frac{V_{in} - V_{be}}{I_b + I_{bf}} \left[\frac{I_b + I_{bf}}{I_{RT}}\right]$$

Using Eq. (4) and (1):

$$R_T = R_{T1}\left[1 - \frac{I_{off}}{I_{RT}}\right]$$

substituting Eq. (2) gives:

$$R_T = R_{T1}\left[1 - (N_i - 1)\,\frac{V_{be} - V_{ce}}{R_T \cdot I_{RT}}\right]$$

and Eq. (3) gives:

$$R_T = R_{T1}\left[1 - (N_i - 1)\,\frac{V_{be} - V_{ce}}{V_{in} - V_{be}}\right] \quad (5)$$

$R_{T1}$ is defined for $N_i = 1$.

As $N_i \rightarrow N'_{i\,max}$, $R_T$ must approach 0. Substituting $R_T = 0$ and $N_i = N'_{i\,max}$ in Eq. (5) gives:

$$N'_{i\,max} = \frac{V_{in} - V_{be}}{V_{be} - V_{ce}} \quad (6)$$

For $N_{i\,max}$ an integer, Equation (6) is an inequality, and

$$N_{i\,max} \leqq \frac{V_{in} - V_{ce}}{V_{be} - V_{ce}} \quad (6a)$$

For the output circuit, the following equation can be written (neglecting the clamp):

$$V_{cc} - N_0\, I_{RT}\, R_L \geqq V_{in} \quad (7)$$

Because of the clamp action, maximum load occurs when Eq. (7) is an equality. Assuming $V_{cc} >> V_{ce}$

$$N_{0\,max} = \frac{I_c}{I_{RT}} \quad (8)$$

$N_{0\,max}$ is the maximum fan-out possible before the output swing is less than the clamp allows. This is not a failure, but is a limit on predictable performance since the input swing is assumed constant. The actual maximum fan-out is an integer less than the maximum fan-out. To operate at maximum fan-out calls for an infinite supply voltage. The supply voltage required to provide the design fan-out can be written from Eq. (7) as:

$$V_{cc} = \frac{V_{in}}{1 - \frac{N_0}{N_{0\,max}}} \quad (9)$$

†See Appendix—List of Symbols.

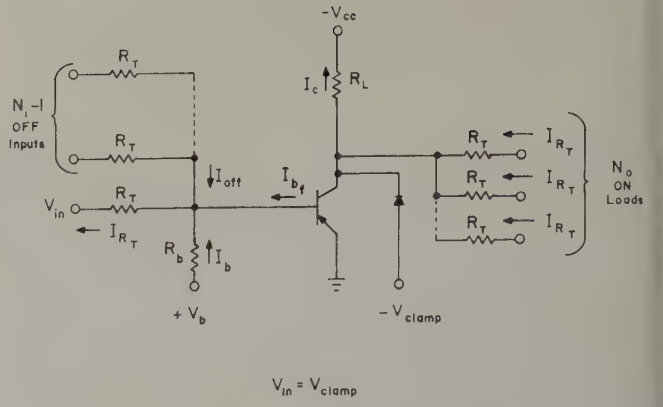



**Fig. 1—TRL Design Circuit.**

Equating the input and output circuit equations gives the three following equations:

$$\frac{R_T}{R_{T1}} = N_{0\,max}\,\frac{I_{bf} + I_b}{I_c} = \beta_i\, N_{0\,max} \quad (10)$$

$$N_0 = N_{0\,max}\left(1 - \frac{V_{in}}{V_{cc}}\right) = N_{0\,max\,(1-\alpha)} \quad (11)$$

$$N_i = \left(1 - \frac{R_T}{R_{T1}}\right)\left(\frac{V_{in} - V_{be}}{V_{be} - V_{ce}}\right) = \left(1 - \frac{R_T}{R_{T1}}\right)\mu \quad (12)$$

Eq. (10) through (12) can be plotted as shown in *Fig. 2*, and used with Eq. (4) to design the complete TRL stage. It is necessary to:

(1) determine the transistors saturation parameters
(2) determine the relationship between $I_b$ and $I_{bf}$
(3) select $N_{0\,max} > N_0$ (the design fan-out)
(4) select $N_i$, the minimum fan-in required

By using the common factors between equations, a three quadrant plot results, and is used by starting at the $N_0$ intersection and working clock-wise, around the loop. One or two trials will give whole number values that can be satisfied with standard tolerance components.

For an example, consider the following design for a 2N501 transistor.

$V_{in} = 5$ volts
$I_c = 20$ ma
$V_{ce} = 0.15$ volts
$V_{be} = 0.30$ volts
$\beta_{min} = 20$
} saturated conditions

The desired loading conditions are:

$N_i > 5$
$N_0 = 5$
$N_{0\,max} > 6$

Experience with a particular transistor dictates the relationship between $I_b$ and $I_{bf}$.

Let $$I_b = 2\, I_{bf}$$

Then, starting at $N_0 = 5$, the curves give:

$$\frac{V_{in}}{V_{cc}} = 0.2, \text{ for } N_0 = 5, \text{ and } N_{0\,max} = 6.3$$

Since $$\frac{I_{bf} + I_b}{I_c} = 0.75$$ (consider this an inverse circuit $\beta$)

$$\frac{R_T}{R_{T1}} = 0.475 \text{ and } N_i = 17.5$$

This shows that fan-in is not usually a problem unless very large base currents are used.

Equation (4) gives $R_{T1} = 3.14$ K

Selecting standard values gives,

$R_T = 1.5$ K
$V_{cc} = 24$ volts
$R_L = 1.2$ K

Since $\beta_{min} = 20$, $I_{bf} = 1.0$ ma, and $I_b = 0.5$ ma

Taking $V_{be}$ into account,

$V_b = 1.5$ volts, and $R_b = 2.4$ K

would give the required bias current.

If minimum propagation time is desired, bench testing will give the optimum $I_b$ for this design, since the $I_b$ supply controls the degree of transistor saturation, and the turn-off reverse drive. The collector clamp diode lessens the circuit dependence on $N_0$ since the output swing stays constant. A test circuit gives a propagation delay that is constant with fan-out, but decreasing with fan-in. Changing $I_b$ to 0.8 ma ($\beta = 25$, $I_b = I_{bf}$, $V_b = 1.9$v) gives a stage delay of 35 $\pm$1 nanosecond, substantially independent of input or output load for the range of

$$1 \leq N_i \leq 9$$
$$0 \leq N_0 \leq 5$$

Thus, the effect of the output clamp can be seen to provide minimum sensitivity to load by providing a constant input voltage. Because the transistor is always driven into saturation harder than indicated for maximum load, rapid turn-on is assured. Rapid turn-off can be assured by proper use of the input and bias networks. For a balanced propagation time at turn-on and turn-off, some adjustment of $I_b$ will be necessary.

Although this method of designing does not take all worst-case variations into account, it offers a very quick, simple, and reliable method for designing a test circuit. Component tolerances can be taken into account by setting a higher maximum fan-in and fan-out than needed. Since bench testing for optimum performance is common, this allows the *d-c* design to be taken into account during optimization.

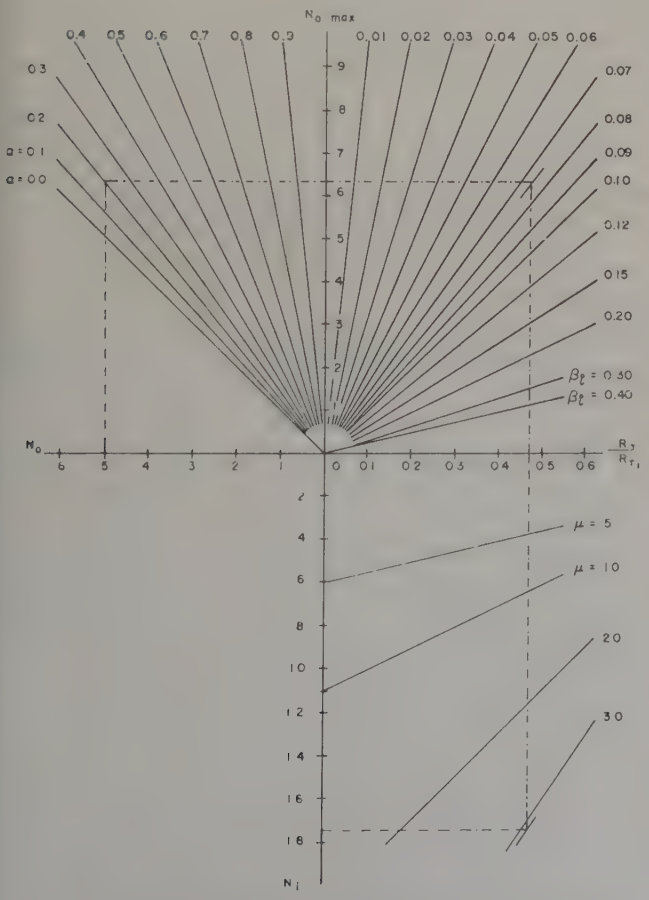



**Fig. 2—Graphical plot of TRL design equations.**

### Appendix—List of Symbols

$I_b$ — current through bias resistor $R_b$
$I_{bf}$ — transistor forward base current
$I_c$ — collector saturation current
$I_{off}$ — total current from all *off* inputs
$I_{RT}$ — current through one *on* input coupling resistor
$N_i$ — number of logical inputs, gate fan-in
$N_{i\,max}$ — calculated maximum fan-in, not necessarily an integer
$N_0$ — number of logical outputs, gate fan-out
$N_{0\,max}$ — calculated maximum fan-out, not necessarily an integer
$R_b$ — base reverse bias resistor
$R_L$ — collector load resistor
$R_T$ — gate input resistor
$R_{T1}$ — gate input resistor when fan-in is one
$V_b$ — base reverse bias voltage
$V_{be}$ — transistor base-emitter saturation voltage
$V_{cc}$ — collector supply voltage
$V_{ce}$ — transistor collector-emitter saturation voltage
$V_{clamp}$ — collector clamp voltage
$V_{in}$ — gate input voltage (equal to $V_{clamp}$ for ideal clamp diode)
$\alpha$ — $\dfrac{V_{in}}{V_{cc}}$
$\beta_i$ — $\dfrac{I_{bf} + I_b}{I_c}$, inverse circuit beta
$\mu$ — $\dfrac{V_{in} - V_{be}}{V_{bc} - V_{ce}}$

# The Silicon Trinistor, A High-Power N-P-N-P Triode Switch

F. S. STEIN* E. W. TOROK**

**The Silicon Trinistor, a three-terminal three-junction semiconductor device, has been developed for high-current high-temperature switching applications. Design considerations and performance are discussed. Currents up to 50 amperes at room temperature and 20 amperes in ambient temperatures up to 150°C can be switched, with gate triggering currents of approximately 10 milliamperes. Breakover voltages and reverse breakdown voltages range up to 400 volts. Breakover currents are 1-10 milliamperes. Turn-on times of less than a microsecond are observed. The switch has a great number of applications.**

IN THE FIELD of high-power switching applications, the most promising solid-state device appears to be the *npnp* switch. Designations for this device, in its various guises, include *pnpn* transistor switch[1], solid-state thyratron[2], four-layer diode[3], *pnπn* switch[4], Dynistor[5], Thyristor[6], Controlled Rectifier[7], and Trinistor[8]. The name "Trinistor" is here recommended for the three-terminal *npnp* switch, because it indicates, first, that the switch is a *trio*de, thus distinguishing it from two-terminal switches; and second, through the similarity between the names Transistor and Trinistor, that the latter functions by virtue of transistor action and contains a control, or base, electrode.

The purpose of this article is to discuss the design considerations and device characteristics of high-power silicon Trinistor controlled rectifiers. Devices rated at 20 amp. *d-c* in ambients of 150-200°C and up to 50 amp. at room temperature, with power handling capacities of the order of 5-10 *kva*, will be treated with respect to their design, fabrication, and performance.

The general switching characteristics of the *npnp* device are well known. At low emitter currents in the forward direction, the impedance is high, corresponding to the "off" condition of the switch. At higher currents the blocking voltage breaks over and the switch becomes a low-impedance device; this is the "on" condition. The breakover voltage, and to a small extent the breakover current, are controlled by the magnitude of the base current. In general, this type of device may be used for circuits currently employing conventional thyratrons or relays, serving in a great number of applications.

We will first examine the salient properties of the switch and the design considerations involved in its fabrication.

## Design Considerations

Three factors are of primary importance in the design of power switches, for moderate frequencies:

(1) the power dissipation, in both the "off" and "on" conditions;

(2) the current carried in the "on" condition;

(3) the voltage sustained in the "off" condition.

These factors, which are to some degree interdependent, will be considered individually, below.

### Power Dissipation

As in the case of power rectifiers, only a small fraction of the power is dissipated in the blocking states of the switch. The dissipation in the control circuit is also small. Thus, only the dissipation in the conducting state must be considered. The most severe case, specified for military applications, requires an ambient of 200°C. Thus, in order to switch 20 amp *d-c* in this extreme ambient, the dissipation will be approximately 20 watts, assuming a one-volt forward drop. In order to limit junction temperature to, say, 240°C, a maximum total thermal resistance of 40°C/20 watt, or 2 deg/watt, is thus established.

The total thermal resistance, 2 deg/watt, may be considered as the sum of two major contributions: junction to case, and fin to ambient. The latter may be expected to predominate. Measurements show that a 6 x 6-inch blackened copper radiating fin in still air has a thermal resistance of aproximately 1.5 deg/watt; this leaves 0.5 deg/watt for junction to case. Considering the solder layers and the molybdenum or

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tungsten electrode between the silicon wafer and the copper case, it may be calculated that the diameter of the silicon must be in the neighborhood of ¼ inch. The silicon diameter was therefore chosen as ⅜ inch, to provide a comfortable margin of safety. With larger fins or forced air cooling, the junction will operate at lower temperatures.

### Current Capacity

The emitter current density will be discussed next. It is important in this connection to note that the emitter current will be uniformly distributed over the emitter area, even at high current densities, inasmuch as the device is truly a diode in operation. This is in contrast to the situation in the transistor, where high current densities result in concentration of the current at the emitter periphery, with deterioration of performance. In this device, at 50 amps, the current density is approximately 100 amp/cm$^2$, which is not excessively high.

### Voltage

The desired voltage rating may be inferred from the power handling and current ratings, since the maximum power which can be switched is the product of the breakover voltage rating and the load current. To switch 10 *kva*, for example, a pair of 50-amp units must each be rated at 200 volts or 20-amp units at 500 volts. It is therefore apparent that the highest possible voltage rating is desired.

Power switches have been developed with breakover voltages exceeding 700 volts at room temperature. However, voltages in the range 200-400 volts are typical. Thus, with suitable mounting, it is possible to switch powers of the order of 10 *kva*.

Achievement of high breakover voltages has resulted from analysis and careful control of design parameters. It has been shown that the breakover voltage in a *pnpn* switch is somewhat lower than the breakdown voltage would be in an identical diffused diode.[1] It has also been observed that diffused junctions and linear graded junctions behave similarly with respect to breakdown characteristics.[9] Thus, it has been possible to analyze diffused junctions, taking into account the variation of maximum electric field with breakdown voltage which has been found for graded silicon *p-n* junctions.[10] It may be shown[8] that the breakdown voltage depends primarily on the product of the initial resistivity, $\rho$, of the silicon and the diffusion length, $L$, of the impurity. The approximate relations for the breakdown voltage, $V_B$, in volts, are as follows ($L$ in cm., $\rho$ in ohm-cm.):

$$V_B \approx 2000\ (L\rho_n)^{0.36} \qquad (n\text{-type base}) \qquad (1)$$

$$V_B \approx 1500\ (L\rho_p)^{0.36} \qquad (p\text{-type base}) \qquad (2)$$

As stated above, breakover voltages will be slightly lower than the breakdown voltages calculated from Eq. (1) or (2).

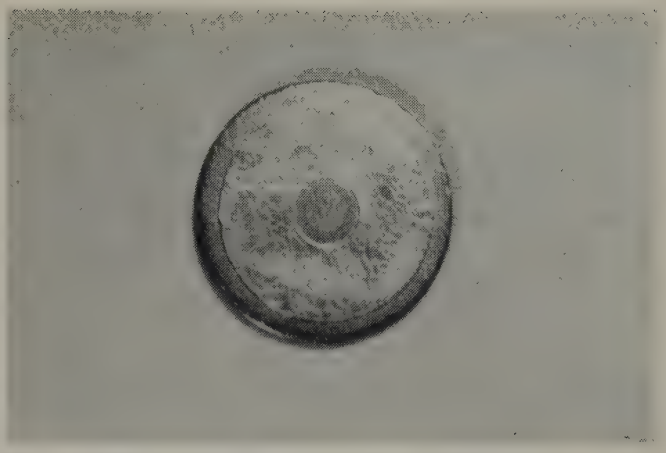

**Fig. 1—Photograph of unmounted Trinistor. Central base dot is *p*-type; annular emitter is *n*-type.**

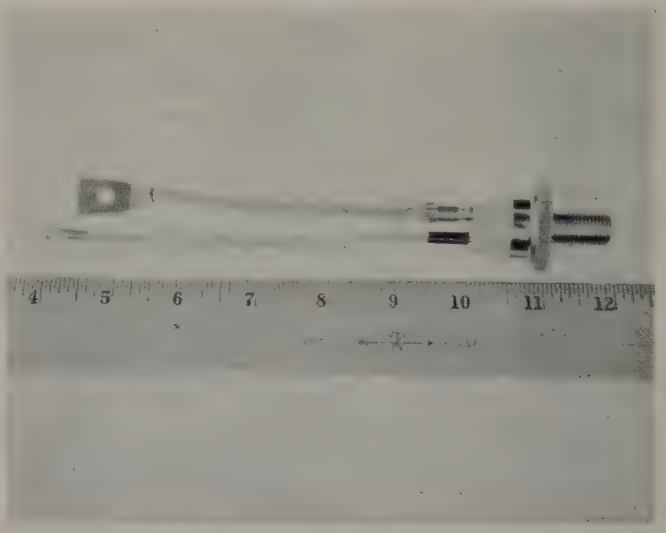


**Fig. 2—Trinistor encapsulation.**

### Fabrication

The Trinistor controlled rectifier is of the *npnp* variety with the control electrode at the *p*-type base. An unmounted unit is shown in *Fig. 1*. Slices of *n*-type silicon are subjected to solid-state diffusion, the diffused layers serving both as the *p*-type base, or gate, and the *p*-type emitter, or anode. The *n*-type emitter, or cathode, is then formed by alloying an annular gold foil to one side of the diffused silicon wafer, with a central contact to the gate. Hard solders are used to affix the wafer to a tungsten or molybdenum disc and the latter disc to a studded copper base with attached weld ring. A glazed ceramic hat, with two leads, is welded to the base to complete the assembly. The encapsulated Trinistor is shown in *Fig. 2*.

### Performance

The performance of the switch will now be described in terms of its electrical characteristics and response times.

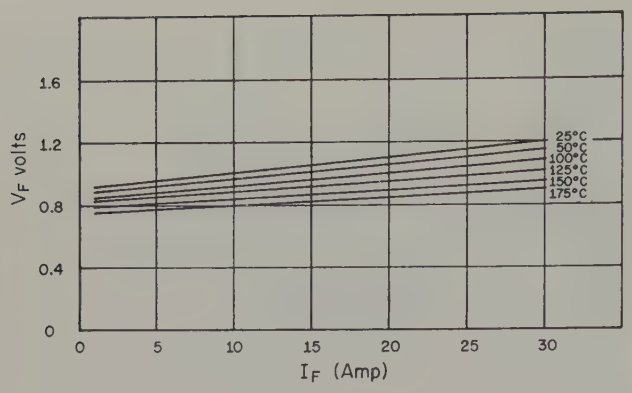


**Fig. 3—Forward pulse characteristics of Trinistor, with temperature as parameter, in "on" state.**

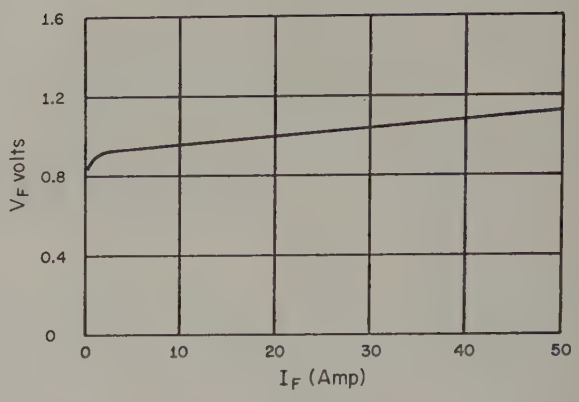


**Fig. 4—D-C forward characteristic in "on" state.**

### Forward Drop

The forward characteristic, as measured with short current pulses, is illustrated as a function of temperature in *Fig. 3*. *Fig. 4* portrays the forward characteristic for *d-c* currents up to 50 amp., with the switch mounted on a blackened 6 x 6-inch copper fin in still air. The forward drop is approximately one volt at 20 amp., with a temperature rise of the copper base of 30 deg. C above ambient; and 1.1 volt at 50 amp. with a temperature rise of 80 deg. The forward *d-c* resistance is only a few hundredths ohm; the differential resistance, only a few thousandths ohm. As a consequence of the low forward drop, very high efficiencies may be achieved.

### Efficiency

In a single-phase symmetrical switching circuit, two switches are employed. The efficiencies may be readily approximated. The output of the circuit is given approximately by the product $V_0 I_F$, where $V_0$ refers to the actual standby voltage, which is somewhat lower than $V_{B0}$, and $I_F$ is the maximum forward current in the "on" state. The losses are primarily due to the forward dissipation, given by $V_F I_F$, where $V_F$ is the forward drop. Thus, the efficiency is given approximately as

$$E = 1 - V_F I_F / V_0 I_F, \qquad (3)$$

or

$$E = 1 - V_F / V_0 \qquad (4)$$

Since $V_F$ is 1.0-1.1 volt and $V_0$ is 150-400 volts, the efficiency is well over 99%. Because of the relatively constant forward drop, it is apparent that higher standby voltages lead to higher efficiencies.

### Breakover Voltage

Breakover voltages generally lie in the range of 200-400 volts, although higher or lower values occur. Standby currents are in the range of 1-10 *ma*. With a forward base current, $i_B$, applied, the breakover voltage may be reduced to any desired level; the breakover current will simultaneously increase slightly. This behavior is illustrated in detail in the characteristic curve of *Fig. 5*. For this particular unit, the breakover voltage is 200 volts; the family of curves is shown with a 10 *ma d-c* bias imposed on the base. The base firing current is seen to be 42 *ma*. With a standby voltage of 150 volts, the base firing current for this unit is about 23 *ma*. Typical room-temperature base firing currents are 10-50 *ma*, with corresponding base-emitter voltages of 1-3 volts.

The temperature behavior of the breakover voltage is of great interest. Breakover voltages may remain essentially constant from 25°C up to 125-150°C. However, further increase of the ambient temperature to 200°C will generally reduce the breakover voltage by 50% or more. The temperature performance of a high-voltage switch is illustrated in *Fig. 6*. Here, a unit with $V_{B0} = 640$ volts at 25°C is heated by two different methods:

(a) in the left-hand curve, by passing varying load-currents through the Trinistor (*rms* values are labeled parenthetically), and

(b) in the high-hand curve, by oven-heating without load current.

The magnitude of the breakover voltage in its temperature-dependent region serves as a measure of the junction temperature, thus allowing the thermal resistance, junction-to-case, to be inferred. Typical values are 0.3-0.4 deg C/watt.

### Reverse Voltage

In the reverse quadrant, the switches offer a high impedance to voltages which are somewhat in excess of the breakover voltages. The peak inverse voltage or breakdown voltage will therefore aproximate the breakover voltage. The ratings are considerably simplified for this reason, as only one blocking voltage need be specified regardless of polarity.

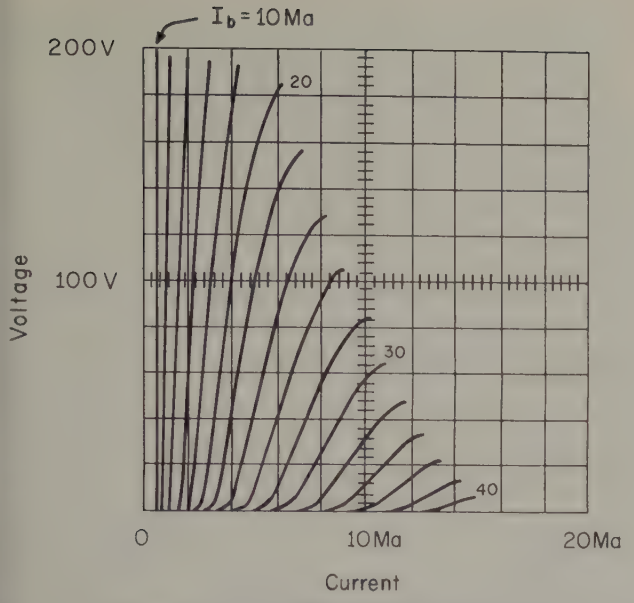


**Fig. 5—Oscillogram of "off" characteristics, with base current as parameter. Base bias current is 10 *ma d-c* plus 2 *ma* per step. Base firing current is 42 *ma*.**

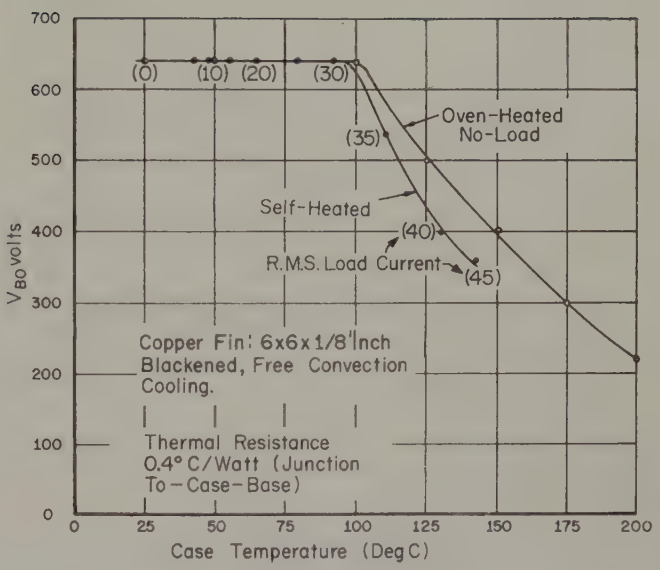


**Fig. 6—Breakover voltage as a function of temperature.**

### Response Times

The switch under discussion has a very fast turn-on time, because of the central location of the base connection. The turn-on time consists of a delay time plus a rise time, both of which are illustrated in *Fig. 7* as a function of load current. For base currents two or three times the minimum base firing current, the total turn-on time is approximately one-half microsecond.

Like the turn-on time, the turn-off time also comprises two contributions, the storage time and the recovery time. In *d-c* circuits, turn-off by means of the base electrode is convenient only at low current levels, and turn-off can generally be effected only by reducing the load current to a value of a few milli-amperes. The turn-off values at one ampere are illustrated in *Fig. 7*. It is seen that the recovery time predominates, being 15-20 microseconds, the storage time being only a few microseconds. In *a-c* circuits, there is no difficulty in turning off large load currents, as turn-off occurs automatically every cycle as the *a-c* voltage reverses polarity.

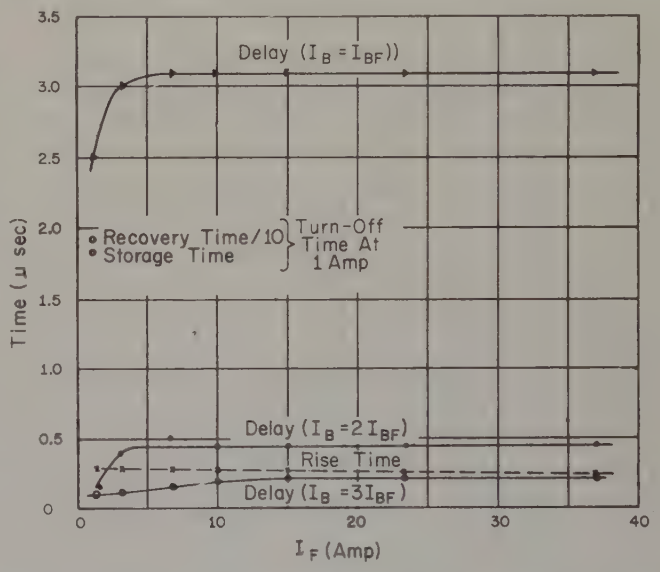


**Fig. 7—Turn-on and turn-off times as a function of load current.**

### Conclusion

In summary, the design, fabrication, and characteristics of a high-power three-terminal silicon *npnp* switch have been described. This device, termed a Trinistor, is rated at 20-50 amps, depending on ambient temperature conditions, and can block up to 300-400 volts at elevated temperatures. Switching speeds are very high. Power handling capacity is in the neighborhood of 10 *kw*, with efficiencies exceeding 99%. Trinistors of higher current and power handling capacities have also been developed.

### Acknowledgment

This work has been supported in part by the Electronic Components Laboratory of the Wright Air Development Center. The authors are pleased to acknowledge the helpful discussions and suggestions of J. Philips and H. C. Chang of the Westinghouse Materials Engineering Department which contributed significantly to the development of this device.

### References

1. "P-N-P-N Transistor Switches," J. L. Moll, M. Tanenbaum, J. M. Goldey, N. Holonyak. *Proc. IRE*, **44**, 1174-82 (1956); "Three Terminal P-N-P-N Switching Devices," I. M. Mackintosh. *IRE Trans. on Electron Devices*, **ED-5**, 10-12 (1958).
2. "Solid State Thyratron Switches Kilowatts," R. P. Frenzel and F. W. Gutzwiller. *Electronics* **31**, 52-55 (1958).
3. "Unique Properties of the Four-Layer Diode," W. Shockley. *Electronic Industries* **16**, 58 ff (1957).
4. "PNπN Switches," J. A. Hoerni and R. N. Noyce. *IRE Wescon Convention Record* 2, Part 3, 172-175 (1958).

5. "The Dynistor Diode, A New Device for Power Control," A. P. Kruper. 21st Annual Machine Tool Electrification Forum, Buffalo, N.Y., April 1957; "Germanium Power Switching Devices," J. Philips and H. C. Chang, *IRE Trans. on Electron Devices* **ED-5**, 13-18 (1958).
6. "The Thyristor—A New High-Speed Switching Transistor," C. W. Mueller and J. Hilibrand. *IRE Trans. on Electron Devices* **ED-5**, 2-5 (1958).
7. "Multiterminal P-N-P-N Switches," R. W. Aldrich and N. Holonyak, Jr. *Proc. IRE* **46**, 1236-1239 (1958).
8. "Comparison of NPN Transistors and NPNP Devices as Twenty Ampere Switches," H. W. Henkels and F. S. Stein. *IRE Trans. Electron Devices* **ED-7**, 39-45 (1960).
9. "Avalanche Breakdown Voltage in Silicon Diffused P-N Junctions as a Function of Impurity Gradient," H. S. Veloric, M. B. Prince and M. J. Eder. *J. Appl. Phys.* **27**, 598-899 (1956).
10. Data supplied by K. G. McKay for *Fig. 1* in Ref. 9.

# A Transistorized Count Rate Meter*

PHILIP GOLDSTEIN**

**This article describes a transistorized count rate meter suitable for general laboratory or field use with scintillation detectors or Geiger tubes. It is stable, accurate, has eight linear counting scales, and is capable of counting up to 3 x $10^4$ counts/sec. full scale. It has an adjustable time constant so that the instrument can be conveniently used for either quick checking or more accurate radiation surveying.**

A count rate meter may be used to measure the repetition rate of uniformly spaced pulses (such as produced by a pulse generator) or randomly spaced pulses (as produced by a nuclear radiation detector). At the heart of most such devices is a capacitor, called the tank capacitor, upon which a given charge is placed for each input pulse. A resistor placed across the tank capacitor allows it to discharge and in the equilibrium state the voltage on the capacitor reaches a value dependent on the input pulse rate. Various types of circuits, called pump circuits, may be used to deliver the standard charge pulse to the tank capacitor. One type of pump circuit frequently found on portable meters consists of an emitter coupled univibrator with the tank capacitor in the collector of the *off* transistor. Everytime the univibrator is triggered, a standard charge is delivered to the capacitor. One disadvantage of this circuit is that the delivered charge is a function of the univibrator on time, a quantity that in this case is neither stable nor precisely determined.

The diode pump circuit shown in *Fig. 1* is capable of greater precision and stability, and has been described in detail in the literature.(1) If the following conditions are satisfied: (2)

$$RC_2 >> \tau >> T > 5R_sC_1,\ C_1 << C_2,\ V_{C2} << E$$

then during each pulse a charge $q = EC_1$ is placed on $C_2$. Between pulses $C_1$ discharges rapidly through $D_1$ and $R_s$, the output impedance of the pulse source. $C_2$ can then discharge only through $R$ with the time constant $RC_2$ which is made larger than the time between pulses. In equilibrium, $nq$, the rate at which charge is dumped into $C_2$, is the same as the rate at which $C_2$ discharges through $R$. Thus the current in $R$, given by

$$i = nq = nEC_1$$

depends only on $E$ and $C_1$. The quantity $RC_2$, called the circuit time constant, indicates the speed with which the output current responds to changes in input pulse rate, and is independent of the counting rate.(3)

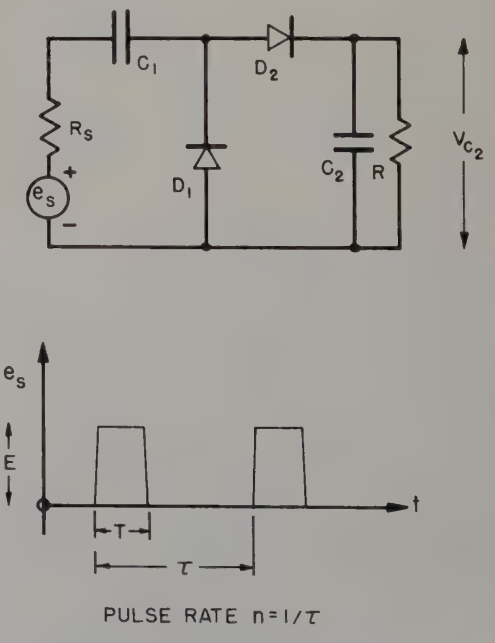


**Fig. 1—Diode pump circuit.**

(1) Elmore and Sands, "Electronics," McGraw-Hill, p. 249. Millman and Taub, "Pulse and Digital Circuits," McGraw-Hill, p. 346.
(2) The exact formula is derived later.
(3) When the input pulse rate is subject to statistical fluctuations, it is necessary to use a large time constant with low pulse rates in order to keep the fractional probable error $e = 0.67(2nR_sC_2)^{-\frac{1}{2}}$ small. See Elmore and Sands, ibid.

* The work described in this article was performed at Palmer Physical Laboratory, Princeton University, and was supported in part by the AEC.

** Now at RCA Laboratories, Princeton, N.J.

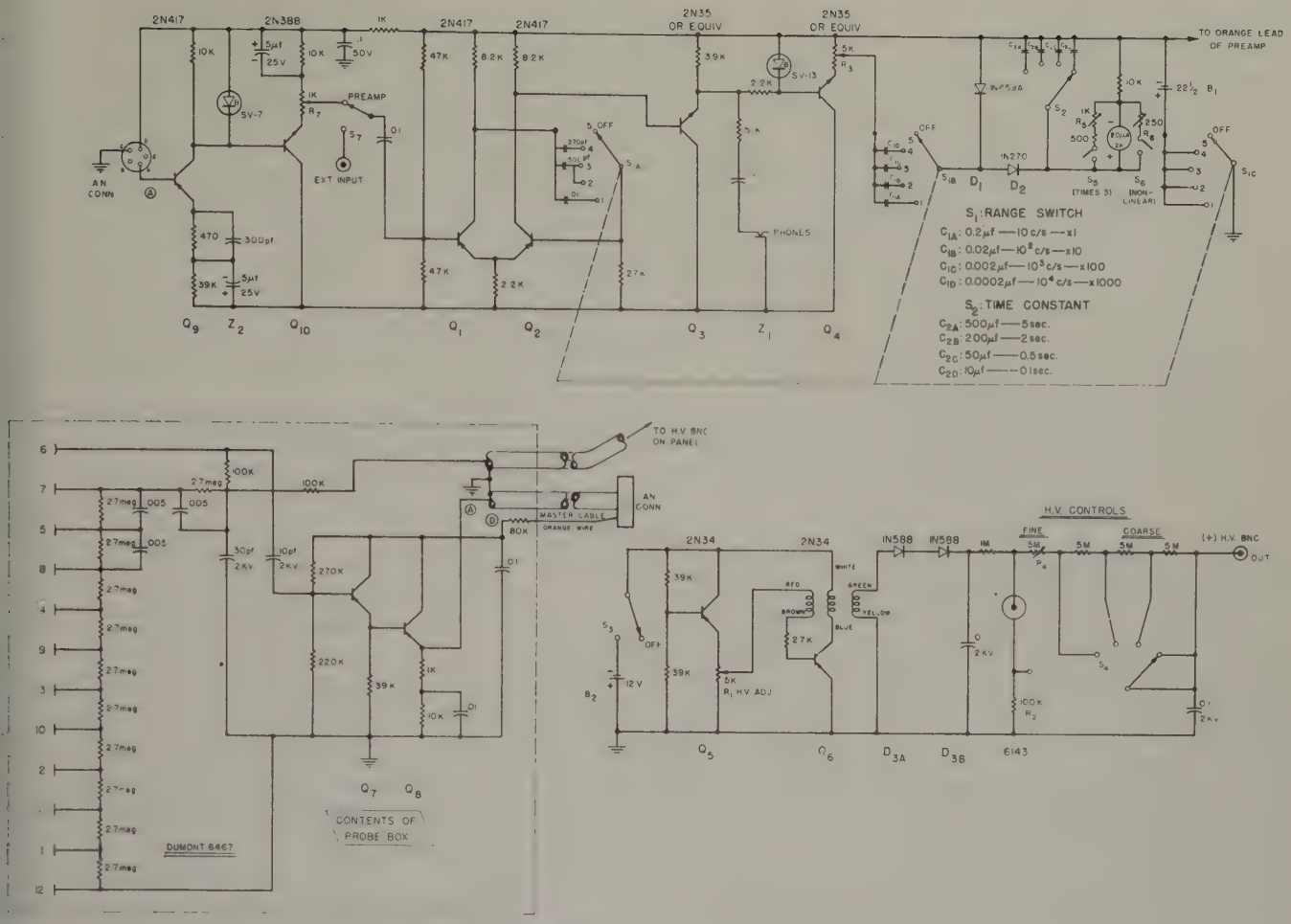


**Fig. 2—Schematic of count rate meter.**

By using accurate and stable capacitors for $C_1$ (such as silver mica, polystyrene, or mylar), and a clamping circuit to define $E$, good accuracy and stability are insured with a minimum of adjustment. It is clear that this circuit is insensitive to reasonably large variations in $T$.

A portable meter containing a high voltage supply for use with a scintillation counter is shown in *Fig. 2*. The actual count rate circuit is composed of Q1, Q2, Q3, Q4, Z1, D1, D2 and associated components. The circuit has been designed for maximum versatility. Thus S7 allows one the option of counting pulses from the standard detector or from any other desired source. The high voltage supply may also be used independently of the rest of the unit.

The operation of the count rate circuit may be described as follows: Q1 and Q2 form a univibrator with Q1 normally *on* and Q2 normally *off*. A one volt positive pulse, 0.7 μsec. or longer will trigger the circuit producing a 16 volt positive pulse, $V_u$, at the collector of Q2. Q3 and Q4 are emitter followers (normally biased *off* to reduce battery drain) which prevent loading of the univibrator by the pump circuit and any audible indicator such as earphones or loudspeaker that might be used.

Z1 is a Zener diode used as a clamp to provide a standard size pulse of about 11 volts to Q4. The calibrate potentiometer, $R_3$, is then adjusted with a known input pulse rate to give the proper reading on the meter. The instrument should then be accurately calibrated on all scales. The values of $C_1$ in *Fig. 2* have been calculated for a 10 volt input signal and the ranges shown. For full scale deflection $V_{C2} = 0.2$ volts thus insuring linearity of the output meter scale. Since $V_u$ is much larger than the Zener breakdown voltage, the circuit is insensitive to large fluctuations or long term drifts in $V_u$. As a result satisfactory operation is obtained until B1 drops to about 15 volts.

The number of ranges may be doubled by converting the 20 $\mu a$ meter to 60 $\mu a$. This is done by closing $S_5$ and properly adjusting $R_5$. This extends any range that $S_1$ is set to by a factor three. Since $V_{C2} = 0.6$ volts (still $<<$ 10 volts) for full scale deflection, good linearity is maintained. This technique has the advantage of allowing a reasonable overlapping of ranges without increasing the number of precision capacitors needed.

It is sometimes convenient to have a scale that can cover several decades of counting ranges simultaneously. One way such a scale may be obtained with this instrument makes use of the fact that as $V_{C2}$ becomes comparable to $E$, the charge placed on $C_2$ for each input pulse decreases significantly. As we have seen, such operation is to be avoided when a linear

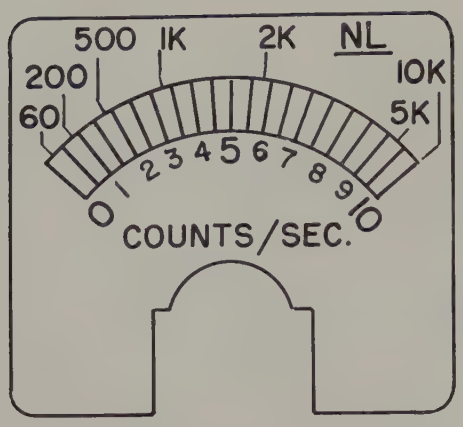


**Fig. 3—A possible scale configuration.**

scale is desired, but it provides the basis for a non-linear scale. Various types of non-linear scales are possible depending on the range of maximum interest. One possible scale is shown in *Fig. 3*. This scale is produced with $S_5$ open, $S_6$ closed, $S_1$ in position two, an input pulse rate of $10^4$ pulses/sec., and $R_6$ adjusted so that the meter reads full scale. While not as convenient as a logarithmic scale, it is quite satisfactory for many purposes, and it doesn't depend on a semiconductor whose properties may drift or change with temperature.

The radiation detector and high voltage supply complete the circuitry shown in *Fig. 2*. The detector consists of a sodium iodide crystal mounted on a 6467 photomultiplier tube. The double emitter follower circuit of Q7 and Q8 is mounted right at the output of the phototube, and together with it form the contents of the probe box. The negative pulses from Q8 are inverted and amplified by Q9 whose output is fed via emitter follower Q10 to the counting circuit. $R_7$ acts effectively as a gain control. Z2 is a seven volt Zener diode used to limit the output of Q9.

High voltage for the phototube is obtained by rectifying, filtering, and then regulating the output of the free running blocking oscillator[4] Q6. The supply will deliver over 30 $\mu a.$ at 1200 volts. The 6143 high voltage regulator tube requires at least 10 to 15 $\mu a.$ in order to regulate properly. If $R_1$ is adjusted at full load (30 $\mu a.$) so that the voltage $R_2$ (as measured with a high impedance meter such as a *vtvm*) reads at least 1.2 volts, proper regulation at lower load currents is assured.

A similar circuit has also been used with a Geiger counter as the detector. In this case the auxiliary circuitry can be made much simpler. Q7 and Q8 are not needed and $R_7$ may be a fixed resistor since pulses from a Geiger tube are all of uniform size. If the pulses are big enough they may be fed directly via a pulse inverting transformer to Q1 thus eliminating Q9 and Q10. Furthermore, since Geiger tubes will generally operate satisfactorily with large fluctuations in the high voltage supply, no high voltage regulator tube is needed. If the blocking oscillator is powered by a mercury battery, sufficient regulation of the high voltage is obtained over the life of the battery provided that the bleeder used draws more current than the Geiger tube. The highest counting ranges and the 0.1 second time constant are also unnecessary.

To obtain the exact relationship between the current through the meter, whose internal resistance is $R$, and the average counting rate $n$, assume $R_s = 0$. Then if $v$ is the voltage on $C_2$, the charge delivered to $C_2$ is $q = C_1 (E - v)$. In particular if $v$ is the average voltage on $C_2$ at a counting rate $n$, then

$$v = iR = nqR = nC_1R (E - v) \text{ or}$$
$$v = nC_1RE/(1 + nC_1R)$$

and therefore $i = v/R = nC_1E/(1 + nC_1R)$

A number of these instruments have been built at this laboratory and have performed satisfactorily with a minimum of maintenance.

(4) The transformer used was obtained from Atomic Accessories, Long Island.

# Observations On Semiconductor Device Reliability

HAROLD J. SULLIVAN* LOWELL L. SCHEINER**

**This article is based on papers presented at the *Conference on the Reliability of Semiconductor Devices*, held in New York City on January 12 and 13, 1961, under the sponsorship of the Working Group on Semiconductor Devices of the Department of Defense. The article presents some of the highlights brought out at the Conference with reference to causes of semiconductor-device degradation, means employed to detect these causes, and ways of improving device reliability.**

WITH THE GROWING USE by the military of semiconductor devices in highly complex electronic systems, engineers and scientists are becoming increasingly aware of the need for adequate quantitative knowledge about semiconductor-device reliability. In this area, where for so long information has been scarce and sketchy, there are now strongly concentrated efforts to correct the situation. Major testing programs involving large

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umbers of devices and lengthy test eriods have been undertaken, and the esults of this activity are now becom- g apparent. Papers presented at the ecent *Conference on the Reliability of emiconductor Devices* clearly in- icated how industry is attacking the roblem of failure in devices which nould, theoretically, be failure-free.

An interesting report on the testing f semiconductor devices in large-scale ystems use was given by the Interna- onal Telephone and Telegraph Com- any. The paper related failure pat- erns of transistors and semiconductor iodes employed in a large-scale digital ata-handling system for more than wo billion device-hours. About half f the 1.1 million components in the ystem were such semiconductor de- ices as germanium *pnp* and *npn* alloy- unction transistors and germanium liodes of both the point-contact and he gold-bonded types.

Diode failures which occurred in the ystem's flip-flop circuits involved pri- narily collector-clamping units and the ase-reverse-voltage-limiting diodes. These devices comprised 42 of the 53 lip-flop circuit failures, and the in- vestigators gave the following reasons or the breakdowns: (1) subjection of he units to strong current transients, nd (2) simultaneous blowing of the hree series-connected diodes situated between the "set" or "reset" terminals and voltage sources.

In the emitter-follower circuits, there were no degradation failures but several externally-induced catastro- phic ones. Self-destruction occurred when the output terminal was con- nected to a negative voltage. In such a case, excessive conduction destroyed the transistor or the associated col- lector-clamping diode.

From the standpoint of long-term degradation, there were no failures of gold-bonded diodes in the gate circuits. In the open-circuit mode, however, there were many more failures of the gold-bonded units than of the point- contact units.

For the entire system, the observed failure rate was about 0.022 percent per 1000 hours for both transistors and semiconductor diodes. If the two de- vice types are considered separately, then the transistor failure rate becomes approximately 0.0678 percent per 1000 hours and the diode failure rate be- comes 0.0142 percent per 1000 hours.

General Electric investigators re- ported on operating-life tests conducted with germanium *pnp* alloy transistors for periods up to 40,000 hours. One transistor type studied was the 2N43, a germanium *pnp* alloy-junction triode. This is a low-frequency device em- ployed for high-gain and low-power applications. At 30,000 hours an $I_{CBO}$ degration failure occurred; after 40,560 hours of operation, the failure pattern of 15 units tested showed one $I_{EBO}$ and two $I_{CBO}$ degradation failures and one $I_{CBO}$ catastrophic failure. This pattern indicated to the investigators two types of failure mechanism: one, which is an abrupt failure mechanism, follows upon large magnitude of collector-base volt- age; the other, which comes into play very gradually, shows degradation at high collector-bias test voltage ($V_{CB}$ = 45V) and also decreases the small-sig- nal *a*-c gain at low-bias test voltage ($V_{CB}$ = 5V).

The researchers also conducted tests on the 2N525, a low-frequency ger- manium *pnp* alloy-junction triode for low-to-medium power amplifier and switching applications. Two significant findings highlighted this series of tests. In the first place, after 10,000 hours, failure rate at 115° C oven storage was approximately twice that at oven stor- age of 85° C. Secondly, in comparing the failure rate of those devices tested under operation-life and cycled-life conditions and those tested under con- ditions of oven storage at 115° C, it was observed that the storage-test units and the cycled-life test units had the largest degradation failure rates. The devices subjected to operating-life tests had the highest number of catastrophic failures.

A third series of tests pertained to the 2N396, a germanium *pnp* alloy- junction, medium-frequency switching transistor. An oven-storage test at 100° C was found to be more severe than a 150-*mw* cycled-life test (about 50 *mw* below rated power dissipation). Excel- lent stability was observed with regard to $I_{CBO}$, $I_{EBO}$, and $h_{FE}$ on units operated at lowered voltage and power (75 *mw*) in a cycled-life test which exceeded 19,000 hours.

Some interesting failure modes were studied at Airborne Instruments Lab- oratory, both in the germanium alloy- junction 2N597 and T-1841 and in the silicon grown-junction 2N337 and 2N338. Failure of the germanium units was found to be caused by breakdown of the silicone rubber coatings in the glass-to-metal hermetic seals when the devices were exposed to humid condi- tions. With respect to the silicon de- vices, failure resulted when surface leakage paths formed subsequent to vibration-stressing tests. These tests produced the flaking-off of particles from the case of the transistor and their eventual deposition on the junctions.

A significant finding was made with reference to packaging of the silicon units. It was discovered that units hav- ing glass-to-metal hermetic seals, made at the transistor leads with glass beads, successfully withstood (1) shock and vibration stressing, (2) thermal cycling, and (3) humidity exposure. No failures were observed in devices packaged in this way.

Reliability engineers at Airborne In- struments also designed an interesting test to determine if power levels ex- isted that seemed safe, but were, in fact, injurious to reliability. The in- vestigators pulsed transistor base- emitter junctions in reverse for seven seconds at different power levels. Pulse duration and interval were selected so that junction temperature would cycle from ambient to maximum on each pulse. An $I_{CBO}$ above five microamperes was the criterion of failure. The first power level employed was 400 milli- watts; on the first pulse, four of the five test units broke down, and the fifth failed on the second pulse. At 200 milliwatts, it seemed, a safe power level was found, since none of the devices failed after receiving 130 pulses. Ac- cordingly, 200-mw pulse life tests were started. $I_{CBO}$ and $BV_{CBO}$ were read in- itially and at the 48-, 168-, 336-, 750-, and 1000-hour intervals. An $I_{CBO}$ failure occurred in one unit after 48 hours. The investigators calculated the mean- time-to-failure to be 9,048 hours. Lower limit of mean-time-to-failure, at the 90 percent confidence level, was found to be 3,920 hours. This lower limit sug- gested that the devices, when pulsed at 200 milliwatts, were not reliable and, hence, circuits should be designed ac- cordingly. Just what the appropriate power level was had not yet been de- termined, but the investigators reported that 75 milliwatts appeared to be the limit of safe operation.

An important study relating the re- liability of germanium alloy transistors (both *pnp* and *npn* computer types) to etching, washing, and encapsulation processing was carried out at the Syl- vania Electric Products Company. The units had dissipation ratings of 150 *mw* at 25° C. They were enclosed in welded Kovar-seal TO-5 cases. The investi- gators found that, during 100° C stor- age of *npn* units, devices etched in modified hydrogen peroxide solution (containing the complexing agent tetra- sodium ethylene diamine tetraacetate) degrade some 2000 hours later than those etched in regular hydrogen per- oxide solution (containing no complex- ing agent). It was concluded that the delay in failure of the devices etched in the solution containing the complex- ing agent indicated a lower impurity concentration on their surfaces. In tests on the washing of these same types of devices, it was found that units spray-washed for five minutes, follow- ing a 20-minute tank-wash, exhibited greater stability than those units merely tank-washed for 60 minutes. For ex- ample, median $I_{CBO}$ and $h_{FE}$ of spray- washed units decreased from 3.9 to 3.0 $\mu A$ and from 118 to 111, respectively, following storage of 3000 hours. The tank-washed devices, on the other hand, showed changes of median $I_{CBO}$ and $h_{FE}$ of 2.6 to 3.7 $\mu A$ and 115 to 120, respec- tively. Testing of *pnp* devices having fluid encapsulants revealed that device stability is associated, at least to some degree, with the initial magnitude of $I_{CBO}$ of the lot tested.

Two key conclusions were drawn: (1) During the testing period, low in- itial $I_{CBO}$ values seemed to be associated with greater stability, and (2) lowest initial values may not necessarily yield highest stability. In general, then, it was concluded after lengthy testing, that there was no evidence of degrada- tion which could be ascribed to fluid encapsulants used.

Reliability information of consider- able interest about silicon devices was presented in a Bell Telephone Labora- tories paper describing work done to characterize the reliability of a broad line of advanced-design silicon tran- sistors and diodes. This program ex-

plored the following broad categories of failure mechanism:

(1) *Mechanical* (such causes of breakdown as hermetic-seal deterioration, internal leakage, metal-semiconductor contact failures, etc.).

A major difficulty causing mechanical breakdown of these advanced-design units was cracking in the glass seal, which resulted from poor tolerance of the piece-parts and from mismatching of the thermal expansivities of the piece-parts. This problem was found very difficult to eliminate. In fact, the only answer at present would appear to be employment of strict manufacturing controls and meticulous package design.

(2) *Electrical* (due to transients in current and power).

Failures due to electrical breakdown of the devices were found to be caused by burnout of the lead wires in high-frequency operation and the appearance, during testing, of voltage transients greatly exceeding the rated junction peak-reverse voltages. The use of constant-current power supplies in the testing equipment is the direct cause of the appearance of these transients. The power supply terminals rise, under open-circuit conditions, to their maximum voltage. When the transistor is connected, the energy which has been stored in the capacitances of the power supply is discharged into the device and this causes rapid deterioration. This phenomenon, it has been emphasized, is caused by electrical abuse—and is *not* a manufacturing defect. Solution is effected by the placing of voltage limiters on all constant-current power supplies that are used for test purposes.

(3) *Ambient* (the adverse effects of water vapor and other surface impurities on solid-state devices).

The investigators encapsulated a medium-power, high-speed silicon switching transistor in a vacuum-secure package. The unit was vacuum-baked at 200° C at a manifold pressure of approximately $10^{-5}$ millimeters of mercury. Leak-testing was conducted with helium mass-spectrometer, after which the device was vacuum-sealed. It was found that aging of the transistor under power resulted in an increase in leakage current. The observed failures were typical of "leakers," when moisture content within the enclosure was sufficiently high to effect excessive reverse leakage. Reliability improvement was noted, however, following the introduction of higher vacuum-baking temperatures. Moreover, the use of Vycor moisture getters successfully lowered the moisture content and thus increased device life expectancy.

(4) *Materials*. Device failure from materials breakdown has been observed to result from (a) natural breakdown of semiconductors, and (b) inadvertent enclosure of foreign materials during encapsulation of the device. Such causes of failure are both difficult to detect and hard to correct.

Through the utilization of gettering elements in both germanium *pnp* alloy transistors and silicon grown-junction transistors, the General Electric Company has been able to raise device lifetime. Under 100° C storage temperature conditions, the onset of degradation in the germanium devices has been moved out to the 30,000-100,000-hour period. With the silicon grown-junction units (also containing the gettering elements) at a storage temperature of 200° C, a similar effect has been observed. The investigators pointed out that the limited temperature range available for "acceleration" use (up to 135° C for germanium alloy transistors, up to 250° C for silicon grown-junction transistors, and up to 300° C for silicon mesa devices) makes it highly improbable, in the case of well-processed transistors, that it will be possible to accelerate measurable degradation failure rates into the customary 1000-hour test period.

What this apparently indicates, according to the General Electric investigators, is that engineers are becoming more cognizant of the great importance of operating-life tests as a criterion of reliability. Transistors are operated, rather than stored, in the circuits in which they are used. It is therefore felt that operating tests, rather than storage tests, will produce failure mechanisms and degradation rates more in accord with what is expected in actual use.

A recurring query raised by equipment people appears to have received at least a partial answer in a paper presented by engineers of the Radio Corporation of America. The question is: How can life-test results be utilized as a prognosis of degradation rates in field equipment? The RCA investigators have devised a method for defining the acceleration factor relating the life-test results to conditions of transistor application in the field, and for employment of life-test results in predicting the most probable rate of failure for a device under any combination of power dissipation and ambient temperature—within given limits.

In their experiments, the RCA engineers specified life tests for some 7,800 transistors with a total accumulation of better than 7.6 million device-hours. The specifications called for lot-acceptance life tests of 1000-hour duration. The life tests to which the lots were subjected consisted of, (a) storage testing at maximum rated temperature, and (b) operation testing at a combination of temperature and power dissipation such that the transistor was subjected to an environment lying along its maximum stress line. The investigators reported that 120 failures occurred; the failure rate was 1.57 percent per 1000 hours. Analysis has shown that the chief influences on the failure rate were the interactions of the effects of power dissipation and ambient temperature. Ambient temperature, it was reported, can, at any chosen power-dissipation level, be raised to a limiting value without critical effect on failure rate. Above this limiting value, however, rise in temperature leads concomitantly to an increase in failure rate. Just what the ambient-temperature limiting values are depends upon the level of power dissipation. The following relationship holds:

$$P'_d = \epsilon^{-3T_A}$$

where

$P'_d$ = The ratio of actual power dissipation to rated power dissipation.

$T_A$ = The ratio of ambient temperature under application conditions (above 25° C) to the rated maximum ambient temperature (above 25° C).

A grid of device-dissipation *vs.* ambient-temperature was prepared to serve as the basis of a nomograph. With the assumption of an exponential form for failure rate as a function of power dissipation and ambient temperature, life-test and field-test data furnished a set of failure contour lines for the nomograph. The engineers stated that, to determine the most probable failure rate for their transistors, four quantities must be known: (1) rated maximum device dissipation, $P_{d\ max}$; (2) rated maximum ambient temperature, $T_{storage}$; (3) ambient temperature under application conditions, $T_A$; (4) power dissipation under application conditions, $P_d$.

$$\text{Normalized } P_d = \frac{P_d}{P_{d\ max}} = P'_d$$

$$\text{Normalized } T_A = \frac{T_A - 25°}{T_{storage} - 25°} = T'_A$$

The operational transistor can be located, for such normalized conditions, on the device-dissipation *vs.* ambient-temperature grid. Should the point of location fall directly on a failure-rate contour line, the value of this line is the most probable failure rate for the device, at the application conditions. If the point falls between two lines, the most probable failure rate lies in the interval subtended by the two contour lines.

This method for prediction of failure rates, by relating life-test results and application conditions, is of especial significance in that it can be applied to the computation of failure rates for any transistor type under any set of application conditions.

During this Conference, it was stated that manufacturers of semiconductor devices are currently in a position to furnish customers with units having failure rates of the order of 0.01 percent per 1000 hours, or better. Within the next few years it is expected that devices will be available that realize failure rates of the next lower order of magnitude; namely, 0.001 percent per 1000 hours. The current major efforts in the study of device reliability, some highlights of which have been presented above, will make a major contribution to this anticipated improvement.

# APPLICATIONS ENGINEERING DIGESTS

## APPLICATIONS ENGINEERING DIGEST NO. 61

*(Circle 199 on Reader Service Card)*

***ideo Amplifiers Using the 2N741 Mesa ransistor;*** Motorola Inc., Semiconduc- or Products Div., Phoenix, Ariz. (W. A. heinfelder)

The advent of the Mesa type 2N741 nakes possible the construction of igh-quality video amplifiers at low ost. Of the various circuits investi- ated, the best appeared to be a two- tage feedback design.

### eedback Circuits and perating Conditions

One of the suggested circuits is shown n *Fig. 61.1.* Feedback is used from the econd stage into the input. An unby- assed emitter resistance of 10 ohm de- relops a feedback voltage which is fed ack through resistor $R_F$ into the base f the first transistor. The local feed- ack introduced simultaneously into he second stage is negligible for the peration of the circuit.

The coupling network between stages ises series peaking in a modified form. Because of the low input impedance of ransistors, the standard form of series eaking is not used, but rather the ob- ect is to deliver maximum current into he coil and the following transistor. Because of the low input impedance of his transistor, the input capacitance is ot important and no tuning of the out- ut end of the coupling network is easible.

The tuning is accomplished at the nput side with the trimmer shown. This single-tuned circuit also provides for good impedance matching. No high-$Q$ coil is required, because for flat re- sponse a $Q$ of approximately 1.5 is needed and an adjustment is provided by the variable series resistor.

### D. C. Operating Conditions

The gain-bandwidth product for the 2N741 is shown in *Fig. 61.2.* The maxi- mum is reached at about 30 *ma*, re- duced by 20% at 7*ma*, and falls off sharply for currents below that amount. In the circuit shown in *Fig. 61.1,* the input impedances of the transistors are also important and optimum results are achieved with an emitter current of 5 *ma* in both stages. At this point the increased input impedance still com- pensates for the fall-off in the gain- bandwidth product, and leads to best over-all performance. A current down to 3 *ma* may be used, but the signal- handling capability is seriously re- duced. The output then available is only one-third of that attainable at 5 *ma*.

For high current stability a separate emitter supply is used. Standard di- vider resistors for the base bias may also be used with a slightly decreased stability.

The second amplifier circuit is shown in *Fig. 61.3.* Here feedback is used from the collector of the second stage into the emitter of the first stage. This feed- back lowers the output impedance and increases the input impedance. A ca- pacitance of 25 *pf* across the output is still permissible at a bandwidth of 10 *mc*. This circuit is more useful for gen- eral applications because of the more favorable impedances, with the input impedances averaging about 500 ohms and the output impedance generally less than 500 ohms depending on the feedback adjustment.

The frequency response adjustments of these two circuits are simple. The tuning is accomplished by the variable capacitor from the collector of the first stage to ground. This permits moving the high-frequency peak to any point desired. The potentiometer in series with the coil permits the $Q$ of this peak to be varied as required to obtain a flat response. These adjustments do not affect the low-frequency gain, which is controlled only by the feedback adjust- ments.

Neither of the previously-mentioned circuits is practical if the output ca- pacitance cannot be kept below the values stated. In *Fig. 61.4* a practical circuit utilizes the second feedback ar- rangement with the addition of an emitter follower. The emitter follower may be designed to work directly into a 50-ohm load but considerable gain is lost in the process and the maximum signal is restricted to about 0.3 volts. Since the remainder of the amplifier is much better in overload characteristic, the emitter follower was designed to operate into a load of 1 kilohm instead, permitting excellent performance of the emitter follower.

### Amplifier Performance

With the values shown in *Fig. 61.4,* a gain of 50.5 *db* was obtained at a 3-*db* bandwidth of 10 *mc*. The maximum output voltage is 1.5 volts for 1-*db* change in frequency response. Under overload conditions, the response tends to become wider and no parasitic fre- quencies or other effects due to insta- bility are noted. Input resistance is 1.5 kilohms; load resistance is 1 kilohm.

With the input terminated with 50 ohms, the noise output is 1.2 *mv* cor- responding to 4.2 $\mu v$ at the input. With the input open circuited, the noise in the output is 6 *mv*, equivalent to 21 $\mu v$ at the input. The thermal noise corre- sponding to a bandwidth of 10 *mc* and a 50-ohm resistor is 3 $\mu v$ (1.5 K$\Omega$ cor- responds to 15 $\mu v$). The noise figure is therefore 20 log $(E_2/E_1)$, or 3 *db*, if noise bandwidth is assumed approxi- mately equal to the 3-*db* bandwidth. Power drain is 20 *ma* at 15 volts.

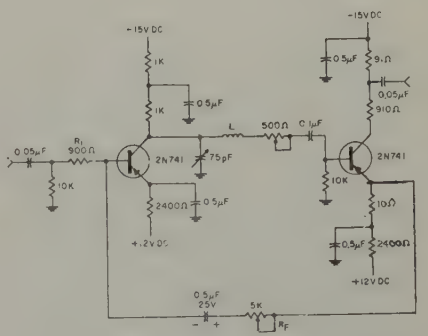


**Fig. 61.1—Feedback amplifier circuit No. 1.**

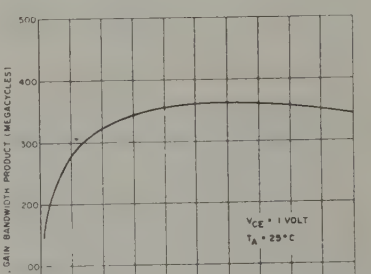


**Fig. 61.2—Gain-bandwidth product vs. Collector current.**

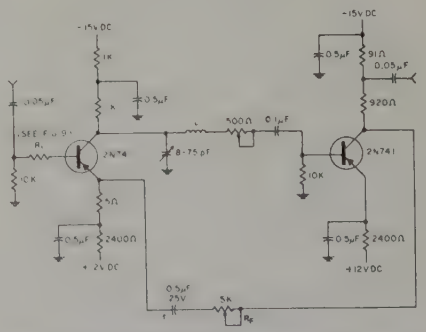


**Fig. 61.3—Feedback amplifier circuit No. 2.**

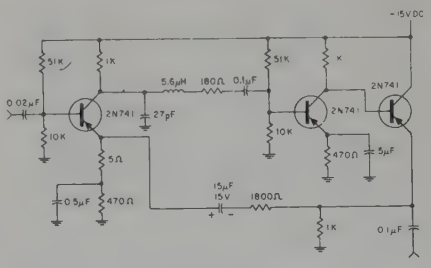


**Fig. 61.4—10 mc video amplifier circuit with 50 db gain.**

# APPLICATIONS ENGINEERING DIGEST NO. 62

*(Circle 200 on Reader Service Card)*

***Silicon Diode Surge Protection;*** Semicon, Inc., Bedford, Mass.

The protection of silicon diodes involves consideration of two types of phenomena: *forward current* surges and *reverse voltage* surges.

In general, a silicon junction is destroyed by overheating, whether from high forward current, high reverse leakage current, high ambient temperature, or any combination thereof. If the time integral of thermal input to the junction exceeds the time integral of junction thermal dissipation, the diode will fail. Such a failure can be relatively gradual if the excess of thermal input is slight, or it can occur in the order of milliseconds for a severe forward current or reverse voltage transient. In addition, failure can result from a reverse voltage transient large enough to cause field or dielectric or related breakdown of the junction.

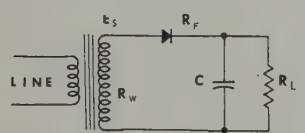


**Fig. 62.1—Half wave circuit.**

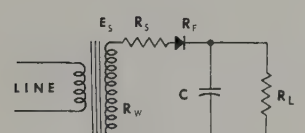


**Fig. 62.2—Half wave circuit with series resistor.**

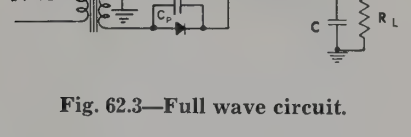


**Fig. 62.3—Full wave circuit.**

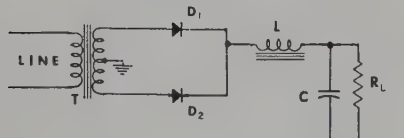


**Fig. 62.4—Full wave circuit with $C_p$ across transformer.**

## Forward Surge Protection

Consider the half wave circuit of *Fig. 62.1.* When this circuit is turned *on, C* represents a momentary short circuit, and a forward current surge will result. The amplitude is determined by the secondary peak voltage $E_s$, the resistance of the winding $R_w$, and the forward resistance of the diode. The amplitude, $A$, of the current pulse is then

$$A = \frac{E_s}{R_w + R_f}$$

Note that $C$ does not appear in the equation, and $A$ is essentially constant regardless of the size of $C$. The duration of the pulse, however, is directly dependent upon the size of $C$, and the thermal energy of the pulse is a function of the product of $A^2$ and $C$. Protecting the diode consists in reducing the product $CA^2$ to within the surge rating of the diode. $C$ must generally be large in such a circuit to provide adequate filtering (40-100 *mfd* for a B+ supply) and so the usual method is to reduce $A$ by adding series resistance, as shown in *Fig. 62.2.* For the full wave supply, the same considerations apply.

## Reverse Voltage Transient Protection

Destructive reverse transients are much more difficult to calculate and analyze than forward surges. Consider the circuit of *Fig. 62.3.*

A short, low impedance pulse on the primary of T will be stepped up by the transformer turns ratio and applied to the non-conducting diode. If the pulse occurs at the peak of the cycle, and if the diodes are operating near their *p.i.v.* rating, the pulse could cause breakdown of the junction. The input choke looks like an open circuit (infinite Z) to a sharp pulse, and hence the filter circuit cannot absorb the energy. Generally, adequate protection can be achieved by the circuits shown in *Figs. 62.4, 62.5* and *62.6.*

In all cases a small capacitor, $C_P$, (100-500 $\mu\mu fd$) is added as shown to provide a short circuit path for fast rise, high voltage pulses. If the rectifier circuit is coupled to any other inductors, such as relay coils, phonograph motors, etc., the value of $C_P$ should be increased to approximately .01 to .1 *mfd.* The circuit of *Fig. 62.6* although offering the most protection is the least desirable in that it increases the ripple in the

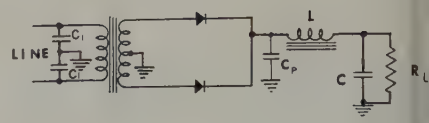


**Fig. 62.5—Full wave circuit with line shunting capacitors.**

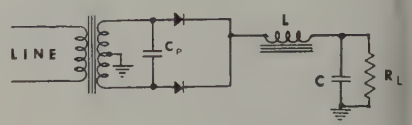


**Fig. 62.6—Full wave circuit with $C_p$ across diodes.**

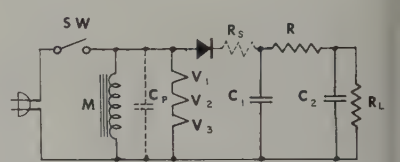


**Fig. 62.7—Ac-dc power supply.**

filter. Inclusion of primary line shunting capacitors (generall about .1 *mfd*), shown as $C_1$ in *Fig. 62.5,* has long been standard practice in well designed equipment, and they are recommended to silicon diode circuits with added urgency.

*Fig. 62.7* shows a very widely used *ac-dc* power supply, designed for low cost phonographs. Note that the series string filaments of $V_1$, $V_2$ and $V_3$ are across the motor, M. The low impedance of these filaments normally protects the diode from the severe reverse transient caused by the motor inductance when the switch is opened. When a tube burns out, however, the protection vanishes, and the diode can easily be destroyed. The remedy is a capacitor, $C_P$, of about .01 *mfd,* shunting the motor as shown.

In addition, because of the low impedance of the power line, a surge limiter, $R_s$, of about 10 ohms should be included in the circuit.

In general, for reverse transient protection, a small capacitor or capacitors should be added in such a manner as will by-pass a pulse, preventing it from appearing inversely across a silicon diode. This is particularly important in half wave circuits, where high impedance for ½ cycle can allow the formation of high voltage pulses.

# PATENT REVIEW*

## Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

*Compiled by* SIDNEY MARSHALL

**The abstracts appearing in this issue cover the inventions relevant to semiconductors from Dec. 30, 1958 to Feb. 3, 1959. In subsequent issues, patents issued from Feb. 3, 1959 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.**

**December 30, 1958**

2,866,858 Wide Band Signal Amplifier Circuit—G. C. Sziklai. Assignee: Radio Corporation of America. A wide band-width, uniform-gain, semiconductor signal amplifier.

2,866,859 Audio Amplifier Bridge Input Circuits—T. O. Stanley. Assignee: Radio Corporation of America. A tone compensated volume control for transistor amplifier circuits which maintains efficient coupling at maximum volume settings and which provides temperature stable operation.

2,866,892 Detector Circuit in Which Increasing Rectified Signal Causes Decreasing Collector Current—L. E. Barton. Assignee: Radio Corporation of America. A configuration which reduces undesired signal distortion and circuit instability.

2,866,925 Transistor Operated Relay—I. Wunderman. Assignee: Lockheed Aircraft Corporation. A relay circuit with portions of the relay inductance in the collector and emitter circuits.

2,866,928 Electric Rectifiers Employing Semiconductors—A. L. Blundell. Assignee: The British Thomson Houston Co. Ltd. A method of preparing a hermetically sealed rectifier device.

2,866,929 Junction Type Semiconductor Devices and Method of Making The Same—T. W. Cooper. Assignee: Hughes Aircraft Company. A method for forming an ohmic contact with an area of an encapsulated junction type semiconductor.

2,866,944 Unidirectional Voltage Control Network for Generator Systems—W. B. Zelina. Assignee: General Electric Company. A regulating circuit develops a signal of high power capacity.

**January 6, 1959**

2,867,043 Variable Electric Resistance Semiconductor Devices—J. M. Jarret, J. H. Jarret. Assignee: Les Applications Electroniques des Caoutchoucs (Frances). Means for producing a vibration between an electrode and a semiconductor element which has a rubber-like elasticity.

2,867,490 Sequence Indicator for Oscillograms—T. Bardeen. Assignee: Gulf Research and Development Co. Transistorized apparatus for indicating a sequence in which oscillographic recordings are made.

2,867,695 Temperature Compensated Direct Current Transistor Amplifier—J. L. Buie Assignee: Hoffman Electronics Corp. An amplifier having uniform characteristics independent of operating temperature.

2,867,727 Method and Device for the Sensing of Neutrons—H. Welker, R. Gremmelmaier. Assignee: Siemens Schuckertwerke A.G. Neutron bombardment of a semiconductor device transmutes the elements thereof and changes the electrical properties of said device.

2,867,732 Current Multiplication Transistors and Method of Producing Same—R. F. Rutz. Assignee: IBM Corp. Means for controlling high current gain in current multiplication transistors.

2,867,733 Current Multiplication Transistors and Method of Producing Same—L. P. Hunter. Assignee: IBM Corp. Means for producing and controlling high current gain of current-multiplication transistors.

**January 13, 1959**

2,867,899 Method of Soldering Germanium Diodes—B. Jacobs. Assignee: International Telephone and Telegraph Corp. A method of electrode soldering not requiring flux or an intermediate layer produces a device with high forward conductivity.

2,868,678 Method of Forming Large Area *P-N* Junctions—W. Shockley. Assignee: BTL. A vapor-solid diffusion method.

2,868,683 Semiconductive Device—P. J. Tummers. Assignee: North American Philips Co. Inc. Means for preventing formation of a layer on the surface of a semiconductive body said layer being of opposite conductivity type from that of the body.

2,868,862 Sealed Casings For Crystal Elements—J. E. Petri. Assignee: American Optical Co. A glass housing for a semiconductor crystal.

2,868,897 Low Output Impedance Semiconductor Amplifier—D. J. Hamilton. Assignee: Hughes Aircraft Co. A transistorized pulse amplifier exhibiting low output impedance characteristics.

2,868,899 Telephone System Subscriber Line Insulation Testing Circuit—E. R. Schmidt. Assignee: General Dynamics Corp. In an apparatus which contains a bistable trigger circuit for each of a predetermined number of line faults, said circuits are triggered to a specified condition when a fault exists in a line.

2,869,001 Semiconductor Devices of Nonlinear Current Voltage Characteristic—H. Welker. Assignee: Siemens Schuckertwerke A.G. (Germany). Pronounced magnetic barrier effect is achieved in devices having a general cylindrical shape.

2,869,002 Transistor Frequency Dividers—J. G. Sperling. Assignee: Emerson Radio and Phonograph Corp. A single-transistor temperature-stable pulse frequency divider.

2,869,053 Transistor Unit—W. A. Schaper. Assignee: Motorola Inc. In the manufacture of a point contact device, preformed metal strips are used as electrodes.

2,869,054 Unipolar Transistor—G. L. Tucker. Assignee: IBM Corp. A method of manufacturing a field effect transistor which provides a control junction shaped to promote pinch off.

2,869,055 Field Effect Transistor—R. N. Noyce. Assignee: Beckman Instruments Inc. A high frequency field-effect device wherein the depletion layer is formed to provide a channel having uniform width.

2,869,056 Semiconductor Device and Method of Making—W. A. Roovers, O. L. Van Steenis. Assignee: North American Philips Co. Inc. An electrode system for semiconductor devices such as diodes and transistors.

2,869,057 Electric Current Rectifier—D. F. Allison. Assignee: International Telephone and Telegraph Corp. A dry dish, high temperature, high forward conductivity, magnesium-telluride rectifier.

2,869,084 Negative Resistance Semiconductive Device—W. Shockley. Assignee: BTL. a two-terminal negative-resistance element having broad frequency response.

**January 20, 1959**

2,870,049 Semiconductor Devices and Method of Making Same—C. W. Mueller, R. L. Sherwood. Assignee: RCA. A vapor diffusion method of manufacturing semiconductor devices.

2,870,050 Semiconductor Devices and Methods of Making Same—C. W. Mueller, J. M. Printon. Assignee: RCA. The method of production involves heating semiconductor wafers in the presence of vapors of a material which has been alloyed with a conductivity-type-determining substance.

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

2,870,052 Semiconductive Device and Methods for Fabrication Thereof—A. D. Rittman. A minority carrier emitter device comprising a transistor having smooth parallel emitter and collector junctions and a high injection efficiency.

2,870,268 Transistor Controlled Low Level Magnetic Amplifier—M. Mamon. Assignee: Magnetic Precision Controls Inc. An amplifier having a power gain of up to 50,000.

2,870,271 Automatic Transmission Regulation—C. I. Cronburg, C. S. Yevtter. Assignee: BTL. A high-linearity-characteristic semiconductor-diode-type repeater regulator circuit.

2,870,309 Zone Purification Device—E. R. Capita. Assignee: None. A device, having movable induction coils, and which permits vibration free mounting of a specimen.

2,870,342 Devices for Amplifying or Converting Radiation—C. H. Walker, M. G. Clarke. Assignee: The British Thomson-Houston Co. Ltd. Solid State device utilizing properties of barium titanate and titanium dioxide performs intensity amplification or frequency conversion of incident radiation.

2,870,344 Semiconductor Devices—W. H. Brattain, G. G. Garrett. Assignee: BTL. A self-powered signal translating device.

2,870,345 Amplification Control of a Transistor—A. J. Van Overbeek. Assignee: North American Philips Co. Inc. Method of providing an amplification control voltage in a dual base transistor.

2,870,347 Bistable Transistor Circuit—A. K. Jensen. Assignee: Monroe Calculating Machine Co. A clock pulse-controlled, high operating-speed, single-transistor circuit.

2,870,348 System for Selectivity Energizing One of Three Circuits Responsive to Variations of Two Conditions—S. C. Chao. Assignee: IBM Corp. A logic circuit.

2,870,413 Modular Circuit Arrangement Comprising Transistors.—J. M. Cluwen. Assignee: North American Philips Co., Inc. A transistor circuit for intermodulating electrical signals from two sources without producing signal source interaction.

2,870,421 Transistor Reactance Circuit—H. C. Goodrich. Assignee: RCA. A broad frequency range transistorized variable reactance circuit.

**January 27, 1959**

2,871,100 Method of Preparing Indium Phosphide—R. J. Gurie, K. Weiser. Assignee: RCA. Controlled temperature gradient of a cooling indium phosphide melt in an atmosphere above ordinary pressure enables production of useful size indium phosphide crystals.

2,871,110 Etching of Semiconductor Materials—R. R. Stead. Assignee: Texas Instruments Inc. Use of an etchant comprising hydrofluoric acid, nitric acid, and sodium dichromate improves surface polishing and cleaning of a semiconductor crystal.

2,871,111 Treatment of Semiconductive Material—D. D. Bacon, J. H. Scaff, H. C. Theuerer. Assignee: BTL. Treatment of silicon crystals with a solution of tetramethyl ammonium hydroxide, and a low dielectric constant liquid increases minority charge carrier lifetime.

2,871,149 Semiconductor Method—K. Lehovec. Assignee: Sprague Electric Co. Production of a junction device by spinning a single crystal plate of material at 10 to 1000 RPM, causing a thin film of opposite type material to form on said plate by dropping liquid semiconductor thereon and forming a base material in like manner.

2,871,174 Method For Electropolishing Semiconducting Material—D. R. Turner. Assignee: BTL. A method of electropolishing $p$-type silicon with an aqueous solution of hydrofluoric acid.

2,871,305 Constant Impedance Transistor Input Circuit—C. R. Hurtig. Assignee: USA (Dept of the Army). The described circuit is effected by providing a grounded base transistor stage with an emitter current controlled compensating impedance between emitter and base.

2,871,330 Silicon Current Controlling Devices—G. B. Collins. Assignee: Gen. Elec. Co. Large temperature range infrared sensitivity and thermosensitive resistivity is achieved in a silicon device.

2,871,354 Oscillators—R. R. Perlman. Assignee: None. An oscillator capable of selectively generating sinusoidal or complex voltage functions.

2,871,376 Temperature Sensitive Transistor Control Circuit—E. R. Kretzmer. Assignee: BTL. A transistor is used to provide a positive temperature coefficient of resistance characteristic in thermalcontrol circuit.

2,871,377 Bistable Semiconductor Devices —W. W. Tyler, R. Newman. Assignee: Gen. Elec. Co. A voltage or radiation controllable bistable circuit using a germanium element.

2,871,378 Stepwave Generator—R. D. Lohman. Assignee: RCA, A transistorized equal-increment step-wave generator.

2,871,379 Pulse Separating Circuits—W. E. Ingham. Assignee: Electric Musical Industries Ltd. (England). A circuit means for separating narrow and broad pulses from a sequence containing both.

2,871,427 Germanium Current Controlling Devices—W. W. Tyler, R. Newman. Assignee: Gen. Elec. Co. A high frequency, high current capacity, infrared sensitive, thermoresistive germanium device for use in the temperature range 0°C to —200°C.

**February 3, 1959**

2,872,581 Current Converter—C. J. Norton. Assignee: Transval Engineering Corp. In a $d$-$c$ to $a$-$c$ transistorized current converter means to allow the switching element therein to operate at voltages below their rated capacity.

2,872,592 Electronic Amplifier—A. H. Dickinson. Assignee: IBM. A bistable positive feedback amplifier with gain greater than one, which is suitable for use as a trigger circuit.

2,872,593 Logical Circuits Employing Junction Transistors—R. A. Henle. Assignee: IBM. AND and OR logic circuits are utilized.

2,872,594 Large Signal Transistor Circuits Having Short Fall Time— J. C. Logue. Assignee: IBM. In a circuit which operates with large value signals pulses, means for preventing saturation of the transistor element under ON conditions.

2,872,595 Transistor Control Apparatus—B. H. Pinckaers. Assignee: Minneapolis-Honeywell Regulator Co. A device which provides $a$-$c$ power output when the signal input is of one phase, and no power to the load when the input is of the opposite phase.

2,872,596 Transistor Voltage Comparator—R. A. Day, L. J. Bateman. Assignee: Hughes Aircraft Co. A voltage comparator that discriminates between voltages within two milliwatts of each other.

2,873,221 Method of Treating Semiconductive Bodies—L. M. Nijland, P. W. Haaijman. Assignee: North American Philips Co. Semiconductor material is treated with a powdered mixture of an active element and a refractory at a temperature at which the active materials is filled from the powder and at which the refractory does not freeze.

2,873,222 Vapor Solid Diffusion of Semiconductive Material—L. Derick, C. J. Frosch. Assignee: BTL. A one-heating step vapor-solid diffusion technique for forming multiple $p$-$n$ junctions.

2,873,303 Photovoltaic Device—E. S. Rittner. Assignee: North American Philips Co. An aluminum antimonide $p$-$n$ junction photo voltaic device.

2,873,316 Party Line Lockout Circuits—J. R. Power. Assignee: BTL. Means for preventing false signaling in a party-line telephone system which uses near voice frequency signaling currents.

2,873,359 Transistorized Radio Receiver—P. W. Cooper, J. F. O'Brien. Assignee: None. A three-transistor miniaturized radio receiver requiring only one voltage source.

2,873,367 Angle Modulation Detector—J. Zawels. Assignee: RCA. A semiconductor circuit for the detection of FM, PM, or hybrid modulated carrier waves.

2,873,371 Variable Frequency Oscillator—R. L. Van Allen. A wide frequency range, multiple remanance core, magnetic coupled multivibrator employing separate frequency control windings.

2,873,372 Electric Circuit Interrupters—F. H. Chase. Assignee: BTL. A transistorized multivibrator is used with mercury contact type relays to regulate the intermittent operation of visual and audible signals at telephone subscriber stations.

2,873,384 Dynamic Pulse Gating Transistor Circuitry—S. Schoen, C. A. Krause. Assignee: National Cash Register Co. A basic computer circuit having standardized input and output configurations so that a plurality of said circuits can be interconnected by logical networks.

2,873,385 Transistor Data Storage and Gate Circuit—B. Ostendorf, Jr. Assignee: BTL. Transistor circuit for providing temporary data storage in high speed telegraph or telemetering systems.

# SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

| TITLE | PUBLICATION | CONDENSED SUMMARY | AUTHORS |
|---|---|---|---|
| New Microwave Techniques . . . Applications and Development | Br Comm & Elecncs Oct 1960 | Survey of progress made in search for lower noise—figure amplifying techniques. | A. P. C. Thiele |
| Printed Circuits Containing Resistors. Part 2 | Br Comm & Elecncs Oct 1960 | Part 1 dealt with the method of production of vacuum-deposited films. The second part deals with testing and production techniques. | P. A. B. Toombs |
| Report on the Conference of Medical Electronics, London, 1960 | Br Comm & Elecncs Oct 1960 | 150 papers were presented on a wide range of electronics instruments for measuring variables such as blood pressure, temperature, and the electrical signals from the brain. | |
| Bulk Photoeffects In Inhomogenous Semiconductors | Can J1 Physics Oct 1960 | A theoretical expression for the bulk photo-e.m.f. is derived for all levels of illumination in the region of arbitrary impurity density gradient. | C. D. Cox |
| P-N-P-N Switches, Diodes and Triodes | Control Engg Oct 1960 | Article discusses the *p-n-p-n* switch starting with an original diode and including the controlled rectifier. | J. M. Goldey |
| Exploiting the Advantages of Silicon Rectifiers | Elecl Des News Oct 1960 | Design procedure and application. | G. E. Wentworth |
| Thermal Resistance Determines Power Safely Dissipated at a Collector Junction | Elecnc Design Oct 12 1960 | If thermal resistance between collector junction and ambient medium is too high, rated power will not be dissipated without excessive heating. | C. Weber |
| Systems Using Transistors and Transductors (Part 3) | Elecnc Engg (Br) Oct 1960 | Discussion of signal magnetic amplifiers in transistor systems, the second-harmonic magnetic modulator, switching transistor power amplifiers, and transductor and switching transistor systems. | D. A. Ramsay |
| The Use of the Silicon Resistor in the *D-C* Stabilization of Transistor Circuits | Elecnc Engg (Br) Oct 1960 | A new method of stabilizing the *d-c* operating point of transistors using the silicon resistor is introduced, and its application to both small-signal and power transistors is expounded. | D. H. Mehrtens<br>J. T. Zakrewski |
| A Cascode Trigger Circuit Using a *P-N-P* and *N-P-N* Transistor | Elecnc Engg (Br) Oct 1960 | The circuit when preceded by a diode pump integrator forms a frequency dividing stage. | P. Arnoldt |
| Static Switching | Elecnc Engg (Br) Oct 1960 | A comparison of existing techniques is made and a complete system employing NOR units as the logic element is described. | G. T. Ohlsen |
| Systems Using Transistors and Transductors (Part 2) | Elecnc Engg (Br) Sept 1960 | Discussion of transistor control element, design formulae, over-volting and unbalancing, transistor ripple reducer, and a transductor stabilized power pack. | D. A. Ramsey |
| The Elliot Sheffer Strobe Static Switching System | Elecnc Engg (Br) Sept 1960 | A system is described in which interconnections between a number of logic elements, all of the same type, permit any logical configuration or switching sequence. | R. Kellett |
| Development of Gain-Stability Design Charts | Elecnc Equip Engg Oct 1960 | When emitter bypassing is not used gain may be made nearly independent of characteristics, and the charts presented here can be used for rapid circuit design. | W. D. Roehr |
| Resistive Load Lines | Elecnc Equip Engg Oct 1960 | A basic tutorial article on resistive load lines. The common emitter oriented transistor is employed arbitrarily as the non-linear element, and a variety of resistor combinations as the linear element. | R. B. Hurley |
| How to Display Tunnel Diode Curves | Elecnc Industries Oct 1960 | Using a simple circuit as described, one can trace the complete characteristic curve, including the negative resistance region, on an ordinary oscilloscope. | R. C. Critchfield, Jr.<br>J. E. Thompson |
| Parametic Amplification by Junction Diodes | Elecnc Industries Oct 1960 | Brief tutorial article discusses a descriptive model, the idler circuit, and circuit parameter evaluation. | E. L. Steele |
| A new Field Effect Device . . . the Alcatron | Elecnc Industries Oct 1960 | The Alcatron makes use of the technology gained from the unipolar transistor and the tecnetron. Physical characteristics and performance are discussed. | A. V. J. Martin |
| Build a Transistor Frequency Meter | Elecnc Industries Oct 1960 | Providing a usable range from 60 *kc* to 70 *mc* this portable meter is ideal for checking laboratory signal generators. | F. R. Bretemps<br>S. Saito |
| Low-Cost Transistor Overload Safety Circuit | Electronics Oct 14 1960 | Transistor across the supply line is cut off by static potential of a diode until an overload occurs. When the transistor conducts, the fuse is opened by the current that would ordinarily destroy the transistors. | K. Redmond |
| Designing Back-Biased Diode Pulse Gates | Electronics Oct 14 1960 | High-speed pulse gates have many applications in electronic circuits and can be designed for pulse widths of a fraction of a microsecond. Gates for both *a-c* and *d-c* signals are discussed. | I. F. Barditch |
| Superconducting Devices and Circuits | Electronics Oct 14 1960 | High-speed switching and storage capability are obtained in superconducting computer circuits with thin-film cryotrons. | D. R. Young |
| Highly Accurate Phantastron Delay Circuit | Electronics Oct 21 1960 | This circuit uses solid-state components throughout and incorporates compensating arrangements to cancel the sources of timing. | D. A. Staar |
| Mechanical Modulator Uses Variable Capacitance | Electronics Oct 28 1960 | Paddle-wheel mechanism provides reliable modulation at constant frequency for landing guidance system. | J. Habra |
| How to Design Silicon Diode AND Gates | Electronics Oct 28 1960 | Factors in the design of silicon diode AND gates are discussed and a chart is presented for quick determination of the gate load resistor to obtain a given threshold voltage. | F. E. Kirkland |
| Semiconductor Electronics 1. Solid State Physics | Electro-Technology Oct 1960 | First article of a six-part series considers the atomic and crystalline structure of materials of all kinds and then applies these principles to semiconductors in particular. | A. A. Sorensen |
| Voltages and Electric Fields of Diffused Semiconductor Junctions | IRE Tr Elecnc Dev Oct 1960 | Equations are developed and graphs are presented showing a functional relationship between electric field and space charge widening; also between reverse bias voltage and space charge widening for diffused diodes. | C. D. Root |

| TITLE | PUBLICATION | CONDENSED SUMMARY | AUTHORS |
|---|---|---|---|
| An Analysis of Inertial Inductance in a Junction Diode | IRE Tr Elecnc Dev Oct 1960 | When the injected carrier concentration is not small compared to the equilibrium concentration, drift and diffusion process interact, and an inductance is developed in the base region. | I. Ladany |
| Avalanche Breakdown Voltages of Diffused Silicon and Germanium Diodes | IRE Tr Elecnc Dev Oct 1960 | Breakdown voltage is computed for various diffused junctions. The calculation process is described and similarities to both linear and abrupt junctions are pointed out. | C. C. Root<br>D. P. Lieb<br>B. Jackson |
| A Silicon Medium-Power Transistor for High-Current High-Speed Switching Applications | IRE Tr Elecnc Dev Oct 1960 | The transistor is designed to operate as a switch at the 0.75 ampere level. For a collector current of 0.75 ampere, the large signal current gain is 20, and the saturation voltage drop is 4 volts. | J. F. Aschner<br>C. A. Bittman<br>W. F. J. Hare<br>J. J. Kleimach |
| Photoeffect on Diffused *P-N* Junctions with Integral Field Gradients | IRE Tr Elecnc Dev Oct 1960 | The illumination, monochromatic or broadband, is applied to the diffused face. Study covers steady-state and transient response; effect of surface recombination velocity is taken into account. | A. G. Jordon<br>A. G. Milnes |
| A Four-Terminal *P-N-P-N* Switching Device | IRE Tr Elecnc Dev Oct 1960 | In an appropriate circuit the device has useful switching gain for both the turn-on and turn-off operation. | M. Klein |
| Fast Neutron Bombardment of Germanium and Silicon Esaki Diodes | JL Appl Phys Oct 1960 | The significant change noticed during the experiments was an increase in excess current proportional to the integrated neutron flux. | J. W. Easley<br>R. R. Blair |
| Anomalous Surface Channels on Silicon *P-N* Junctions | JL Appl Phys Oct 1960 | Determination of the photo response of silicon *p-n* junction surfaces reveals that anamolous channel responses extending as far as 100 mils have appeared on accumulation layer and intrinsic barrier surfaces. | R. Solomon |
| Metal Precipitates In Silicon *P-N* Junctions | JL Appl Phys Oct 1960 | Excess reverse current below avalanche breakdown, which is thought to be due to zener tunneling at localized high field points is caused by metal precipitates in the *p-n* junctions. | A. Goetzberger<br>W. Shockley |
| Oscillations in Germanium with an Applied Pulsed Electric Field | JL Appl Phys Oct 1960 | Current oscillations in uniform germanium single crystals under the influence of a magnetic field are observed in simple circuits having no apparent inductive or capacitive loads. | M. Cardona<br>W. Auppel |
| Anomalous Barrier Capacitance in *P-N* Junctions of InSb | JL Appl Phys Oct 1960 | Measurements of reverse bias transistor capacitance in InSb alloy diodes yield unexplained capacitance values which are three times greater than those predicted by diode theory. | C. A. Lee<br>G. Kaminsky |
| An Improved Method of Growing CdS Crystals From the Vapor Phase | JL Appl Phys Oct 1960 | Means for growing CdS crystals on the inside of a silica tube, rather than on a CdS substrate, includes use of two Kanthal heating elements. | P. D. Fochs |
| Grain Boundary Photo Response | JL Appl Phys Oct 1960 | Grain boundary photo detector sensitivity measurements indicate that power detection may be expected at a minimum of better than $10^{-14}$ watts. | W. W. Lindemann<br>R. W. Mueller |
| Surface Space-Charge Calculations for Semiconductors | JL Appl Phys Oct 1960 | Approximation formulas for the surface excess of carriers at large values of the reduced surface and bulk potentials are derived and presented in graphical form. | D. R. Frankl |
| Hall Field Relaxation in Semiconductors at High Frequency | JL Appl Phys Oct 1960 | The frequency dependence of the complex Hall field is calculated for rectangular, cylindrical, and spherical samples. | K. S. Champlin |
| On the Mechanism of Chemically Etching Germanium and Silicon | Jl Elctrochem Soc Oct 1960 | The results suggest that excess holes and electrons are produced at the surface of the semiconductor during chemical etching. | D. R. Turner |
| Electroluminescence, A Disorder Phenomenon | Jl Elctrochem Soc Oct 1960 | In general, electroluminescence is considered to occur at a junction between a semiconducting crystal and a metal or electron-rich material. The present work indicates that electroluminescence occurs in zinc sulfide powders containing both sphalerite and wurtzite. | D. W. G. Ballentyne |
| Magneto - Electrical Field - Effect Measurements | JL Elecncs & Control Sept 1960 | Further experimental results are given on the influence of combined orthogonal transverse electric and magnetic fields on the mobility of the carriers in the space charge layer at the surface of a semiconductor. | A. Aerts |
| The Light Waveforms Emitted from Electroluminescent Cells Energized by Square Waves and Pulses of Voltage | JL Elecncs & Control Sept 1960 | Light pulses which rise to a maximum in less than 0.2 $\mu$s can be obtained from electroluminescent cells excited by voltage waveforms with fast edges. | G. R. Hoffman<br>D. H. Smith |
| A note on the Method of Determining Ionization Coefficients for Electrons and Holes in Silicon | JL Elecncs & Control Sept 1960 | It is shown that the ionization coefficients need not be equal for symmetrical pairs to have equal breakdown voltages. | R. J. McIntyre |
| Scattering of Hot Carriers in Germanium | Jl Phys Chem Solids Oct 1960 | The variation of lattice mobility of hot carriers with their average energy or "temperature" has been investigated. | E. M. Conwell<br>A. L. Brown |
| The Preparation and the Electrical and Optical Properties of SnS Crystals | Jl Phys Chem Solids Oct 1960 | SnS crystals were prepared by melting the components in an evacuated quartz tube at about 900°C. | W. Albers<br>C. Haas<br>F. van der Maesen |
| Theory of the Absorption Edge in Semiconductors in a High Magnetic Field | Jl Phys Chem Solids Oct 1960 | A theory based on the effective mass approximation is given for hole-electron pairs in a semiconductor in a magnetic field. | R. J. Elliot<br>R. Laudon |
| Transistorized Frequency Stabilization for Reflex Klystrons Used in Magnetic Resonance | Jl Scient Instmnts Oct 1960 | Suitable for magnetic-resonance experiments and other microwave applications. Full description is given. | P. Jung |
| A Simple Method Of Determining The Thermal Conductivity of Solids | Philips Tech Rev Oct 1960 | Method involves no temperature or quantitative heat measurements. The procedure, using a small cylindrical sample, consists merely in taking a stop-watch reading (of a few minutes) and finding a value on a calibration chart. | J. Schroder |
| Scattering Anisotropies in *n*-Type Silicon | Physical Review Oct 1 1960 | Measurements have been made of magneto-resistance effects in several relatively pure samples of *n*-type silicon. | D. Long<br>J. Myers |

| TITLE | PUBLICATION | CONDENSED SUMMARY | AUTHORS |
|---|---|---|---|
| ptical Constants of Silicon in e Region 1 to 10 ev | Physical Review Oct 1 1960 | The reflectance of single crystal silicon was measured in the range 1 to 11.3 ev. | H. R. Philippe<br>E. A. Taft |
| hermoelectricity and Thermal nductivity in the Lead Sulfide roup of Semiconductors | Physical Review Oct 15 1960 | The thermal conductivity and thermoelectric power of six specimens of PbS and one each of PbSe and PbTe have been measured at temperatures ranging from 4° K to 100° K. | D. Greig |
| ee Carrier Absorption Due to lar Modes in the III-V Com- und Semiconductors | Physical Review Oct 15 1960 | A quantum mechanical calculation of the free carrier absorption has been made and gives an absorption varying as $\lambda^{2.5}$. | S. Visvanathan |
| agnetic Susceptibility of *p*-Type e | Physical Review Oct 1 1960 | The magnetic susceptibility of *p*-type Ge has been measured for a range of extrinsic carrier densities extending from $5x10^{17}$ $cm^{-3}$ to $5x10^{20}$ $cm^{-3}$. | R. Bowers<br>Y. Yafet |
| ee Carrier Absorption Arising om Impurities in Semiconduc- rs | Physical Review Oct 15 1960 | The free carrier absorption due to ionized impurities in semiconductors is essentially the inverse process of bremstrahlung. | S. Visvanathan |
| xciton and Magneto Optical Ef- ct in Strained and Unstrained ermanium | Physical Review Oct 15 1960 | Measurements have been made of the direct transition magneto-optic effect in strained and unstrained germanium at 77°K. | D. F. Edwards<br>V. J. Lazazzera |
| heory of Ettingshausen Effect in emiconductors | Physical Review Oct 15 1960 | The Ettingshausen coefficient is calculated in agreement with Putley. | B. V. Paranjape<br>J. S. Levinger |
| ome Considerations in the Ap- lication of Power Rectifiers and onverters | Proc IEE (BR) Oct 1960 | Paper begins with a discussion on the suitability and selection of semiconductor rectifiers and converters, and proceeds to a discussion on the number of phases to employ. | J. P. McBreen |
| RE Standards On Solid-State De- ices; Definitions of Semiconduc- rs Terms | Proc IRE Oct 1960 | Approved by the IRE Standards Committee, Sept. 10, 1959. | |
| hot and Thermal Noise in Ger- anium and Silicon Transistors of igh-Level Current Injections | Proc IRE Oct 1960 | In the present paper, the case of shot noise at high current densities is dealt with for the first time. Formulas in good agreement with experimental values are obtained. The crux of the new theory is the introduction of an equivalent circuit for *p-n* junctions, containing an inductance besides resistances and capacitances. | B. Schneider<br>M. J. O. Strutt |
| A Study of the Charge Control Parameters of Transistors | Proc IRE Oct 1960 | The present status of the concept of charge control of the transistor action is considered, and what appear to be the most significant performance parameters for circuit design purposes are defined; also methods of measuring them are surveyed. | J. J. Sparkes |
| Analytical Studies on Effects of Surface Recombinations on the Current Amplifier Factor of Alloy Junction and Surface Barrier Transistors | Proc IRE Oct 1960 | In this paper, analytical formulas for various idealized geometries are derived by means of approximating methods. From these results, many useful design data such as the optimum radius of the emitter electrode and the collector are obtained and the effect of curvature of the electrode surfaces are made clear. | H. Yanai<br>T. Sugano |
| Field-Effect Transistors in Communications and Signal Processing | RCA Engineer Aug/Sept 1960 | This article describes some of the nondigital applications of the field-effect transistors with emphasis on achieving circuit functions that are difficult to realize with ordinary bipolar transistors. | T. B. Martin |
| Design and Fabrication of Germanium Tunnel Diodes | RCA Engineer Aug/Sept 1960 | Design considerations, design parameters, fabrication techniques, factors affecting characteristics and packaging status. | N. H. Ditrick<br>H. Nelson |
| Gallium Arsenide Tunnel Diodes | RCA Engineer Aug/Sept 1960 | Equivalent circuit, tunnel current, characteristics, device fabrication, and status. | A. J. Wheeler |
| Tunnel Diodes in Digital Computers | RCA Engineer Aug/Sept 1960 | Basic tunnel diode computer circuits, tunnel diodes in memories, and subsystem using tunnel-diode circuits. | R. H. Bergman<br>M. M. Kaufman |
| Tunnel Diodes in Linear Circuits | RCA Engineer Aug/Sept 1960 | General characteristics, amplifiers, oscillators, mixer converter, detectors, and potential problems. | J. B. Schultz<br>H. B. Yin |
| Tunnel Diodes, The Latest Midget Prodigies | RCA Engineer Aug/Sept 1960 | Transit time limitation of bipolar transistors, tunnel diode theory and characteristics, switching speed applications, use in linear circuits, packaging tunnel diodes, and inherent difficulties. | H. S. Sommers, Jr. |
| Introducing the Tunnel Diode | RCA Engineer Aug/Sept 1960 | Key features, operating principle, structure, development, and applications. | D. J. Donahue |
| A Normalized Representation of the Small-Signal Tunnel Diode | RCA Engineer Oct/Nov 1960 | Article develops set of parameters that characterizes the small-signal properties of the tunnel diode and permits universal small-signal admittance curves to be used in the design of tunnel-diode circuits. | |
| Use of Silicon *P-N* Junction Detectors in Studies of Nuclear Reactions Induced by Heavy Ions | Rev Sc Instrmnts Oct 1960 | Experiments in which silicon *p-n* junctions have been used as detectors of fission fragments and elastically scattered heavy ions are described. | A. E. Larsh<br>G. E. Gordon<br>T. Sikkeland |
| Transistor Switching Analysis. Part 2 | Semiconductor Prods Oct 1960 | Diode recovery and diode storage time calculations are discussed: A lumped model of the transistor is developed. | C. A. Mead |
| Introduction to Semiconductor Theory and Reverse Breakdown. Part 3 | Semiconductor Prods Oct 1960 | Reverse, zener, and avalanche breakdown are discussed in this installment; extensive bibliography is provided. | C. A. Escoffery |
| Resistivity, Crystal Perfection, and Lifetime Measurements for Germanium and Silicon Monocrystals | Semiconductor Prods Oct 1960 | A measuring procedure for germanium and silicon monocrystals is outlined in considerable detail. | A. S. Tulk |
| Transistor Choppers | Semiconductor Prods Oct 1960 | Several simple modulator and demodulator circuits are discussed to illustrate how the transistor is utilized in this application. | J. A. Ekiss |
| Absorption of Infrared Radiation By Semiconductors in An Electric Field | Sov Phys Solid State Oct 1960 | A theoretical discussion considers the dependence of absorption on the angle between the radiation polarization and the electric field. | N. V. Fomin |

| TITLE | PUBLICATION | CONDENSED SUMMARY | AUTHORS |
|---|---|---|---|
| Investigation of the Accuracy of the Variational Methods in the Problem of the Impurity Absorption of Light in Silicon | Sov Phys Solid State Oct 1960 | The accuracy of calculations of the energy levels of an optical electron of an impurity atom in silicon is discussed. | V. M. Buimistrov<br>V. N. Piskovoi |
| The Problem of Internal Breakdown in Nonpolar Semiconductors | Sov Phys Solid State Oct 1960 | Internal breakdown is shown to be caused by collision ionization. | G. V. Gordeev |
| Anisotropy of the Surface Breakdown of Germanium in Strong Fields | Sov Phys Solid State Oct 1960 | Experiment involving passage of 10-1000 $\mu$sec, 30 ampere pulses through germanium samples resulted in anisotropic surface breakdown thereof. | A. I. Morozov |
| Certain Peculiarities of Photoconductivity of Mercuric Sulfide | Sov Phys Solid State Oct 1960 | Studies of the rise and decay of photoconductivity show that hexagonal HgS is a member of the hyperbolic photoresistance group. | N. I. Butsko |
| An Investigation of the Semiconducting Properties in the Silicon Cobalt System | Sov Phys Solid State Oct 1960 | Experimental work reveals a clear relationship between the temperature coefficient of electrical conductivity and the chemical composition. | E. N. Nikitin |
| Vitreous Semiconductors . . . Optical Properties of Glasses of Sulphur Group . . . Compounds of Thallium Arsenic and Antimony | Sov Phys Solid State Oct 1960 | A detailed study of optical absorption in the systems mentioned. | B. T. Kolomiets<br>B. V. Pavlov |
| Energy Spectrum For Holes in Diamond Type Crystals | Sov Phys Solid State Oct 1960 | Analytic expressions for the energy spectrum over a wide range of quasimomentum values are obtained. | K. Ya. Shtivel'man |
| Electrical Properties of Certain Semiconducting Oxide Glasses | Sov Phys Solid State Oct 1960 | The electrical conductivity, thermoelectric power, dielectric losses and permittivity of vanadium glasses are discussed. | V. A. Ioffe<br>I. B. Patrina<br>I. S. Poberovskaya |
| Method of Growing Uniform Monocrystals of Alloyed Semiconductor Materials, Solid Solutions, and Intermetallic Compounds of a Given Composition Determined by the Melt | Sov Phys Solid State Oct 1960 | A novel crystal pulling technique for obtaining uniform monocrystals of solid solutions involves flow of a melt through a capillary from a large reservoir to a small one from which the crystal is pulled. | S. V. Airapetyants<br>G. I. Shmelev |
| Surface Properties of Silicon | Sov Phys Solid State Oct 1960 | A study of physical characteristics of silicon yielded information about the densities, the energy positions, and the capture cross section of the surface levels in silicon treated with a standard etcher. | V. G. Litorchenko<br>O. V. Snitko |
| Investigation of the Diffusion of Minority Current Carriers in a Magnetic Field | Sov Phys Solid State Oct 1960 | A theoretical experimental investigation of minority carrier concentration in a magnetic field during point injection. | S. M. Ryvkin<br>Et al |
| Concerning the Effects of Heat Treatment On the Electrical Properties of p-Type Silicon | Sov Phys Solid State Oct 1960 | The effects of heat treatment on specific resistance and carrier concentration in $p$-type monocrystalline silicon are presented. | J. D. Kirvalidze<br>V. F. Zhukov |
| Quantum Efficiency of CdTe $P$-$N$ Junctions in the Ultraviolet Part of the Spectrum | Sov Phys Solid State Oct 1960 | Measurements of the spectral sensitivity of CdTe photocells indicate the existence of electron or hole multiplication when the cells are exposed to ultraviolet light. | G. B. Dubrovskii |
| Thermal Conductivity of P- and $N$-Type Germanium with Different Carrier Concentrations in the Temperature Range 80 to 440° K | Sov Phys Solid State Oct 1960 | Experimental works and tabular data reconfirms the existence of a difference in thermal conductivity between $p$- and $n$-type germanium in the range cited. | D. D. Devyatkova<br>I. A. Smirnov |
| Concerning the Hole-Capture Cross Section of Defects Produced in Germanium by $\gamma$-Irradiation | Sov Phys Solid State Oct 1960 | The hole capture cross section of defects in germanium is shown to be nearly the same for both neutron induced and $\gamma$-ray induced defects. | R. F. Konopleva<br>S. M. Ryvkin<br>I. D. Yaroshetskii |
| Investigations of Crystal Perfection in Semiconductor Crystals | Sylvania Tech Oct 1960 | Chemical etching, decoration and x-ray diffraction microscopy are evaluated for use in the investigation of crystal perfection of semiconductor materials. | G. H. Schwuttke |
| Anisotropy of the Galvanomagnetic Effect in a Germanium Crystal of the $n$-Type at Temperatures in the Conductivity Transition Region | Tech Translations Oct 12 1960 Aked Nauk SSSR | Order from Photoduplication Service, Publication Board Project, Library of Congress, Wash. 25, D.C. $1.80, 60-23178. | R. G. Annayev<br>A. Allanzarov |
| Application of Silicon Diodes to Ring Modulators | Tech Translation Oct 12 1960 Cables et Trans (Fr) | Order from Associated Technical Service Inc., P.O. Box 271, East Orange, N.J., $6.00, -ATS-23M42. | R. Dallemagne |
| The Inertia of p-$n$ Junction Diodes Driven by Strong Sine Waves | Tech Translations Oct 12 1960 Arch Elektr Uber (Ger) | Order from Morris D. Friedman, Inc., P.O. Box 35, New Newton 65, Mass. $5.50, MDF H-104. | W. Heinlein |
| Manufacture of Single Crystals of Pure Silicon | Tech Translations Oct 12 1960 Jap patent 10765 | Order from Associated Technical Services Inc., P.O. Box 271, East Orange, N.J., $6.00, -ATS-23M42. | M. Kawakami |
| On the Possibility of Obtaining Polymer Materials with Semiconductor Properties from Polyacrylonitrile | Tech Translations Oct 12 1960 Alak Nauk SSSR | Order from Office of Technical Service, Dept. of Commerce, Washington 25, D.C. | A. V. Topchiyev<br>M. A. Geyderikh<br>et al |
| Extraction of Tellurium from Some of the Products in Lead Production | Tech Translations Oct 12 1960 Tsvetnyye Metal (USSR) | Description of work carried out in a lead smelting plant. Order from Photoduplication Service, Publication Board Project, Library of Congress, Washington 25, D.C. $3.30, 60-15824. | Ya. Z. Malkin,<br>V. Ya. Sergiyenko<br>et al |
| Analyses of Junction Transistor Converters | Tech Translations Oct 26 1960 Acta Phys Sinica (Ch) | This paper describes a detailed analysis of conversion properties of junction transistors. Order from Off. of Tech. Svcs., Dept. of Commerce, Wash. 25, D.C. $0.50, 60-31323. | Chung-chih Ch'eng |
| Lag in Germanium Diodes and its Effect in Simple Rectifier and Limiter Configurations | Tech Translations Oct 26 1960 Frequenz (Ger) | Order from Morris D. Friedman, P.O. Box 35, New Newton 65, Mass. $13.00, MDF-103. | W. Heinlein |
| A Dream? No, Near Reality | Tech Translations Oct 26 1960 Pravda (USSR) | Prospects for the use of semiconductors discussed. Order from Photoduplication Service, Public Board Project, Library of Congress, Wash. 25, D.C. | A. Ioffe |

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|---|---|---|---|
| Communist China's First Book on Semiconductors | Tech Translations<br>Oct 26 1960<br>Wm Li T'ung Pao (Ch) | Order from Office of Technical Service, Dept. of Commerce, Wash. 25, D.C. | |
| Photo and Thermoelectric Effects in Semiconductors | Tech Translations<br>Oct 26 1960<br>Unident. Czech memo | Order from Pergamon Press, 122 E. 55th St., N.Y. 22, N. Y. | Jan Tauc |
| Solubility of Indium and Antimony in Germanium and Their Influence on Certain Electrical Properties of Germanium | Tech Translations<br>Oct 26 1960<br>Akad Nauk SSSR | Order from Morris D. Friedman, P.O. Box 35, New Newton 65, Mass. $4.00, MDF-Z-126. | B. G. Zhurkin<br>V. S. Zemskov Et al |
| Investigation of Some Semiconductor Switching Elements and Their Application | US Govt Res Repts<br>Oct 14 1960<br>LC $10.80 PB 148,562 | Presentation of general design formulas for a multithrow switch operating at three frequencies. | S. N. Miller |
| The Arc Image Furnace For Growing Semiconductor Crystals | US Govt Res Repts<br>Oct 14 1960<br>OTS $2.50 PB 161,868 | Crucible-free pushing and pulling crystal growing techniques using the image point of the furnace as the heat source are discussed. | R. P. Poplawsky<br>J. E. Thomas, Jr. |
| Observations of Surfact Transverse Magnetoresistance Effects on *n*-type Germanium | US Govt Res Repts<br>Oct 14 1960<br>LC $15.30 PB 148,762 | The magnetoresistance of large surface-to-volume ratio single crystals as a function of sample surface conditions is studied. | W. A. Albers, Jr.<br>J. E. Thomas, Jr. |
| Surface Phenomena in Semiconductors and Growth of Semiconductor Crystals | US Govt Res Repts<br>Oct 14 1960<br>OTS $1.25 PB 161,867 | A study of carrier mobility near the surface of a thin semiconductor filament is presented. | W. A. Albers<br>V. E. Noble |
| Spectral Response of Solar Cell Structures | US Govt Res Repts<br>Oct 14 1960<br>LC $4.80 PB 148,597 | A study of the spectral response of a silicon solar cell as a function of the depth of the *p-n* junction therein. | L. M. Terman |
| Semiconductor Research | US Govt Res Repts<br>Oct 14 1960<br>LC $6.30 PB 146,998 | A collection of 12 papers. | |
| An X-Ray Diffraction Study of Crystal Perfection in Silicon | US Govt Res Repts<br>Oct 14 1960<br>LC $1.80 PB 148,778 | It is shown that short wavelength x-radiation is needed to resolve small differences in crystal perfection. | R. H. Bragg<br>L. V. Azaroff |
| Research Directed Toward the Investigation of Silicon and Silicon Carbide Surfaces | US Govt Res Repts<br>Oct 14 1960<br>LC $6.30 PB 146,388 | A compilation of methods and techniques of studies of silicon. | J. A. Dillon, Jr.<br>R. M. Oman |
| Recycling Dose Rate Meter RGI-20 | US Govt Res Repts<br>Oct 14 1960<br>LC $4.80 PB 148,732 | A transistorized high range gamma dose rate meter. | E. J. Wesley<br>T. L. Sheridan |
| Industrial Preparedness Study on Transistors and Automatic Machinery for Their Manufacture | US Govt Res Repts<br>Oct 14 1960<br>LC $30.30 PB 147,538 | Techniques and equipment for automatic production of devices of the low power germanium audio family. | F. M. Kukat<br>G. Freeman |
| Nuclear Radiation Resistant Power Transistor | US Govt Res Repts<br>Oct 14 1960<br>LC $6.30 PB 148,341 | A discussion of the operational method of preparing these devices. | G. F. Watson |
| Thermoelectricity | US Govt Res Repts<br>Oct 14 1960<br>LC $28.80 PB 147,307 | Results of a conference held at Bureau of Ships in Dec. 1959. | J. W. Davisoon<br>J. Pasternak |
| Air Force Handbook: Methods of Cooling Semiconductor Devices | US Govt Res Repts<br>Oct 14 1960 | Principles and techniques of the thermal design of equipment using semiconductor devices. | S. K. Morrison<br>J. P. Welsa |
| A Semiconductor Magnetron-Modulator | Western Elec Engr<br>Oct 1960 | The modulator, which posed a particularly difficult problem because of its high voltages, yielded to a new design employing *p-n-p-n* switches. | F. A. Gateka |
| Crystal Science | Western Elec Engr<br>Oct 1960 | Discussed are: symmetry elements, crystal systems, x-ray, crystal growing, liquid solution process, fusion process, vapor process, single crystals, dislocation theory, and magnetism. | L. A. Priolo |

# CHARACTERISTICS CHARTS OF NEW DIODES and RECTIFIERS

## MANUFACTURERS

| | |
|---|---|
| AEG— | Allgemeine Elekticitats-Gesellschaft |
| ASC— | American Semiconductor Corp. |
| AMP— | Amperex Electronic Corp. |
| AEI— | Associated Electrical Industries, Ltd. |
| BEN— | Bendix Corp. |
| BER— | Berkshire Corp. |
| BOM— | Bomac Labs |
| BRA— | Bradley Semiconductor Corp. |
| BRI— | Britton Electronics Corp. |
| CBS— | CBS Electronics |
| CDC— | Continental Device Corp. |
| CDLF— | Compagnie des Lampes |
| COD— | Computer Diode Corp. |
| COL— | Columbus Electronics Corp. |
| CON— | Controls Co., of America |
| CTP— | Clevite Transistor Products, Inc. |
| CSF— | (Cosem) Cie Generale des Semi-Conducteurs |
| DEL— | Delco Radio |
| DES— | Delta Semiconductors, Inc. |
| DIC— | Dickson Electronics Corp. |
| EEVB— | English Electric Valve Co., Ltd. |
| ERI— | Erie Resistor Corp. |
| ESP— | Espey Mfg. and Electronics Corp. |
| FAN— | Fansteel Metallurgical Corp. |
| FERB— | Ferranti Ltd. |
| FSC— | Fairchild Semiconductor Corp. |
| GAH— | Gahagan, Inc. |
| GECB— | General Electric Co., Ltd. |
| GE— | General Electric Company, Semiconductor Div. |
| GELC— | Canadian General Electric Co. |
| GIC— | General Instrument Corp. |
| HAFO— | Institutet for Halvedarforskning |
| HITJ— | Hitachi Ltd., Mushashi Works |
| HUG— | Hughes Products Division |
| ITC— | Industro Transistor Corp. |
| IDC— | International Diode Corp. |
| INRB— | International Rectifier Co., Ltd. |
| INRC— | International Rectifier Corp. |
| IRC— | International Resistance Co. |
| ITT— | International Tel. & Tel. Corp. |
| KEM— | Kemtron Electron Products, Inc. |
| KOKJ— | Kobe Kogyo Corp. |
| MAL— | P. R. Mallory & Co., Inc. |
| MATJ— | Matushita Electronics Corp. |
| MIC— | Microwave Associates, Inc. |
| MISI— | Mistral |
| MOT— | Motorola, Inc |
| MUL— | Mullard, Ltd. |
| NAE— | North American Electronics |
| NPC— | Nucleonic Products Co., Inc. |
| OHI— | Ohio Semiconductor Inc. |
| OHM— | Ohmite Manufacturing Co. |
| PHI— | Philco Corp. Lansdale Div., Semiconductor Operations |
| PHIN— | Philips Gloeilampenfabrieken |
| PLEB— | The Plessey Co. |
| PSI— | Pacific Semiconductors, Inc. |
| RADF— | La Radiotechnique Div. Tubes Electroniques |
| RAY— | Raytheon Company |
| RCA— | Radio Corporation of America, Semiconductor Div. |
| RDR— | Radio Development and Research Corp. |
| RHE— | Rheem Semiconductor Corp. |
| HSD— | Hoffman Semiconductor Division |
| ROSG— | Dr. Ing. Rudolph Rost |
| SAR— | Sarkes Tarzian, Inc., Rectifier Division |
| SCN— | Semicon, Inc. |
| SEM— | Semi-Elements Inc. |
| SIE— | Siemens & Halske Aktiengesellschaft |
| SIL— | Silicon Transistor Corp. |
| SGSI— | Societa Generale Semiconduttori |
| SOIF— | Societe Industrial de Liaisons |
| SOD— | Solitron Devices, Inc. |
| SONY— | Sony Corp. |
| SSD— | Sperry Semiconductor Division |
| SSP— | Solid State Products, Inc. |
| STC— | Shockley Transistor Corp. |
| STCB— | Standard Telephone & Cables, Ltd. |
| STCA— | Standard Tel. and Cables Pty, Ltd. |
| SYL— | Sylvania Electric Products, Inc. |
| SYN— | Syntron Co. |
| TEX— | Texas Research Assoc. |
| TFKG— | Telefunken, Ltd. |
| TI— | Texas Instruments Incorporated |
| TKD— | Tekade |
| TRA— | Transitron Electronic Corp. |
| TUN— | Tung-Sol Electric, Inc. |
| TSC— | Trans-Sil Corp. |
| UCI— | United Components |
| UNI— | Unitrode Transistor Prods., Corp. |
| USS— | U. S. Semiconductor Products, Inc. |
| VIC— | Vickers Inc. |
| WEC— | Western Electric Co. |
| WEST— | Westinghouse Electric Corp. |

## CHARACTERISTICS CHART of DIODES and RECTIFIERS

| TYPE NO. | USE (See Code Below) | MAT | PIV (volts) | MAX. CONT. WORK. VOLT. (volts) | Min. Forward Current @ 25°C $I_f$ @ $E_f$ (mA) | ($E_f$ volts) | MAX. D.C. OUTPUT CURRENT[4] (amps) | @ T (°C) | MAX. FULL LOAD VOLT. DROP[4] (volts) | Max. Rev. Current $I_b$ @ $E_b$ @ T (uA) | ($E_b$ volts) | (T °C) | MFR. (See code at start of charts) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1N248C | 2 | Si | 55 | 39 | | | 20 | 150C | .60 | 3.8ma | 55 | 150C | RCA |
| 1N249C | 2 | Si | 110 | 77 | | | 20 | 150C | .60 | 3.6ma | 110 | 150C | RCA |
| 1N250C | 2 | Si | 220 | 154 | | | 20 | 150C | .60 | 3.4ma | 220 | 150C | RCA |
| 1N947 | 1 | Si | | 600 | 400 | 1.0 | 40 | 25 | 1.0 | .002 | 480 | 25 | WEC |
| 1N1195A | 2 | Si | 300 | 212 | | | 20 | 150C | .60 | 3.2ma | 300 | 150C | RCA |
| 1N1196A | 2 | Si | 400 | 284 | | | 20 | 150C | .60 | 2.5ma | 400 | 150C | RCA |
| 1N1197A | 2 | Si | 500 | 355 | | | 20 | 150C | .60 | 2.2ma | 500 | 150C | RCA |
| 1N1198A | 2 | Si | 600 | 424 | | | 20 | 150C | .60 | 1.5ma | 600 | 150C | RCA |
| 1N3193 | 1,2 | Si | 200 | | | | .75 | 75A | 1.2 | 10 | 200 | 25A | RCA |
| 1N3194 | 1,2 | Si | 400 | | | | .75 | 75A | 1.2 | 10 | 400 | 25A | RCA |
| 1N3195 | 1,2 | Si | 600 | | | | .75 | 75A | 1.2 | 10 | 600 | 25A | RCA |
| 1N3196 | 1,2 | Si | 800 | | | | .75 | 75A | 1.2 | 10 | 800 | 25A | RCA |
| 1NA1 | 1 | Ge | 75 | 60 | 5.0 | 1.0 | .05 | 25 | | 500 | 50 | 25 | KOKJ |
| 1NA1G | 1 | Ge | 75 | 60 | 5.0 | 1.0 | .04 | 25 | | 500 | 50 | 25 | KOKJ |
| 1NA2 | 1 | Ge | 125 | 100 | 4.0 | 1.0 | .05 | 25 | | 600 | 100 | 25 | KOKJ |
| 1NA3 | 1 | Ge | 170 | 160 | 3.0 | 1.0 | .04 | 25 | | 500 | 150 | 25 | KOKJ |
| 1NA4 | 1 | Ge | 60 | 50 | 3.0 | 1.0 | .05 | 25 | | 800 | 50 | 25 | KOKJ |
| 1NA4G | 1 | Ge | 50 | 40 | 3.0 | 1.0 | .03 | 25 | | 800 | 50 | 25 | KOKJ |
| 1NA5 | 1 | Ge | 75 | 60 | 5.0 | 1.0 | .04 | 25 | | 100 | 50 | 25 | KOKJ |
| 1NA5G | 1 | Ge | 75 | 60 | 5.0 | 1.0 | .04 | 25 | | 100 | 50 | 25 | KOKJ |
| 1NA6 | 1 | Ge | 50 | 40 | 15 | 1.0 | .06 | 25 | | 300 | 30 | 25 | KOKJ |
| 1NA7 | 1 | Ge | 120 | 100 | 4.0 | 1.0 | .05 | 25 | | 500 | 100 | 25 | KOKJ |
| 1NA9 | 1 | Ge | 35 | 30 | 3.0 | 1.0 | .05 | 25 | | 80 | 10 | 25 | KOKJ |
| 1NA9G | 1 | Ge | 35 | 30 | 3.0 | 1.0 | .04 | 25 | | 80 | 10 | 25 | KOKJ |
| 1NJ11 | 2 | Si | 400 | 140 | | | .50 | 75 | | 100 | 400 | 25 | KOKJ |
| 1NJ12 | 2 | Si | 500 | 175 | | | .50 | 75 | | 100 | 500 | 25 | KOKJ |
| 1S1115 | 1 | Si | 100 | 100 | 500 | 1.1 | 1.5 | 85C | .65 | 400 | | 150 | SGSI |
| 1S1116 | 1 | Si | 200 | 200 | 500 | 1.1 | 1.5 | 85C | .65 | 300 | | 150 | SGSI |
| 1S1117 | 1 | Si | 300 | 300 | 500 | 1.1 | 1.5 | 85C | .65 | 300 | | 150 | SGSI |
| 1S1118 | 1 | Si | 400 | 400 | 500 | 1.1 | 1.5 | 85 | .65 | 300 | | 150 | SGSI |
| 1S1119 | 1 | Si | 500 | 500 | 500 | 1.1 | 1.5 | 70 | .65 | 300 | | 150 | SGSI |
| 1S1120 | 1 | Si | 600 | 600 | 500 | 1.1 | 1.5 | 70 | .65 | 300 | | 150 | SGSI |
| CER67 | 1 | Si | 50 | 50 | 750 | 1.2 | .75 | 25 | 1.2 | 200 | 50 | 100 | SOD |
| CER67A | 1 | Si | 50 | 50 | 150 | 1.2 | .15 | 25 | 1.2 | 200 | 50 | 100 | SOD |
| CER67B | 1 | Si | 50 | 50 | 250 | 1.2 | .25 | 25 | 1.2 | 200 | 50 | 100 | SOD |

## CHARACTERISTICS CHART of DIODES and RECTIFIERS

| TYPE NO. | USE (See Code Below) | MAT | PIV (volts) | MAX. CONT. WORK. VOLT. (volts) | Min. Forward Current @ 25°C $I_f$ @ $E_f$ (mA) | ($E_f$ volts) | MAX. D.C. OUTPUT CURRENT[4] (amps) | @ T (°C) | MAX. FULL LOAD VOLT. DROP[4] (volts) | Max. Rev. Current $I_b$ @ $E_b$ @ T (uA) | ($E_b$ volts) | (T °C) | MFR. (See code at start of charts) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HC71 | 1 | Si | 600 | 600 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 200 | 600 | 100 | SOD |
| HC72 | 1 | Si | 800 | 800 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 200 | 1000 | 100 | SOD |
| HC73 | 1 | Si | 1000 | 1000 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 200 | 1000 | 100 | SOD |
| HC74 | 1 | Si | 1600 | 1600 | 500 | 2.0 | .50 | 25 | 2.0 | 100 | 1600 | 100 | SOD |
| HC75 | 1 | Si | 2000 | 2000 | 350 | 2.8 | .35 | 25 | 2.8 | 100 | 2000 | 100 | SOD |
| HC76 | 1 | Si | 4000 | 4000 | 250 | 4.5 | .25 | 25 | 4.5 | 100 | 4000 | 100 | SOD |
| HC77 | 1 | Si | 5000 | 5000 | 200 | 5.3 | .20 | 25 | 6.3 | 100 | 5000 | 100 | SOD |
| HC78 | 1 | Si | 10000 | 10000 | 125 | 12 | .125 | 25 | 12 | 100 | 10000 | 100 | SOD |
| HC670 | 1 | Si | 50 | 50 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 50 | 100 | SOD |
| HC680 | 1 | Si | 100 | 100 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 100 | 100 | SOD |
| HC690 | 1 | Si | 200 | 200 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 200 | 100 | SOD |
| HC700 | 1 | Si | 400 | 400 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 400 | 100 | SOD |
| HC710 | 1 | Si | 600 | 600 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 600 | 100 | SOD |
| HC720 | 1 | Si | 800 | 800 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 800 | 100 | SOD |
| HC730 | 1 | Si | 1000 | 1000 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 1000 | 100 | SOD |
| SCR51 | 5 | Si | 25 | 25 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR52 | 5 | Si | 50 | 50 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR53 | 5 | Si | 100 | 100 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR54 | 5 | Si | 150 | 150 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR55 | 5 | Si | 200 | 200 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR56 | 5 | Si | 250 | 250 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR57 | 5 | Si | 300 | 300 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR58 | 5 | Si | 400 | 400 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR966 | 5 | Si | 250 | 250 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR967 | 5 | Si | 300 | 300 | | | 10 | 25A | 1.25 | | | | GECB |
| SCR968 | 5 | Si | 400 | 400 | | | 10 | 25A | 1.25 | | | | GECB |
| SFR164 | 2 | Ge | 400 | 400 | | | .50 | 55A | 2.5 | | | | CSF |
| UT234 | 1,2 | Si | 200 | 200 | 1000 | 1.2 | .50 | 150 | .60 | 300 | 200 | 150 | UNI |
| UT235 | 1,2 | Si | 400 | 400 | 1000 | 1.2 | .50 | 150 | .60 | 300 | 400 | 150 | UNI |
| UT237 | 1,2 | Si | 500 | 500 | 1000 | 1.2 | .50 | 150 | .60 | 300 | 500 | 150 | UNI |
| UT238 | 1,2 | Si | 600 | 600 | 1000 | 1.2 | .50 | 150 | .60 | 300 | 600 | 150 | UNI |
| UT242 | 1,2 | Si | 200 | 200 | 1500 | 1.5 | .75 | 150 | .75 | 300 | 200 | 150 | UNI |
| UT244 | 1,2 | Si | 400 | 400 | 1500 | 1.5 | .75 | 150 | .75 | 300 | 400 | 150 | UNI |
| UT245 | 1,2 | Si | 500 | 500 | 1500 | 1.5 | .75 | 150 | .75 | 300 | 500 | 150 | UNI |
| UT247 | 1,2 | Si | 600 | 600 | 1500 | 1.5 | .75 | 150 | .75 | 300 | 600 | 150 | UNI |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CER71 | 1 | Si | 600 | 600 | 750 | 1.2 | .75 | 25 | 1.2 | 200 | 600 | 100 | SOD |
| CER71A | 1 | Si | 600 | 600 | 150 | 1.2 | .15 | 25 | 1.2 | 200 | 600 | 100 | SOD |
| CER71B | 1 | Si | 600 | 600 | 250 | 1.2 | .25 | 25 | 1.2 | 200 | 600 | 100 | SOD |
| CER72 | 1 | Si | 800 | 800 | 750 | 1.2 | .75 | 25 | 1.2 | 200 | 800 | 100 | SOD |
| CER72A | 1 | Si | 800 | 800 | 75 | 1.2 | .075 | 25 | 1.2 | 200 | 800 | 100 | SOD |
| CER72B | 1 | Si | 800 | 800 | 150 | 1.2 | .15 | 25 | 1.2 | 200 | 800 | 100 | SOD |
| CER72C | 1 | Si | 800 | 800 | 250 | 1.2 | .25 | 25 | 1.2 | 200 | 800 | 100 | SOD |
| CER73 | 1 | Si | 1000 | 1000 | 750 | 1.2 | .75 | 25 | 1.2 | 200 | 1000 | 100 | SOD |
| CER73A | 1 | Si | 1000 | 1000 | 75 | 1.2 | .075 | 25 | 1.2 | 200 | 1000 | 100 | SOD |
| CER73B | 1 | Si | 1000 | 1000 | 150 | 1.2 | .15 | 25 | 1.2 | 200 | 1000 | 100 | SOD |
| CER73C | 1 | Si | 1000 | 1000 | 250 | 1.2 | .25 | 25 | 1.2 | 200 | 1000 | 100 | SOD |
| CER74 | 1 | Si | 1600 | 1600 | 350 | 2.0 | .35 | 25 | 2.0 | 100 | 1600 | 100 | SOD |
| CER75 | 1 | Si | 2000 | 2000 | 250 | 2.8 | .25 | 25 | 2.8 | 100 | 2000 | 100 | SOD |
| CER76 | 1 | Si | 4000 | 4000 | 150 | 4.5 | .15 | 25 | 4.5 | 100 | 4000 | 100 | SOD |
| CER77 | 1 | Si | 5000 | 5000 | 100 | 6.3 | .10 | 25 | 6.3 | 100 | 5000 | 100 | SOD |
| CER78 | 1 | Si | 10000 | 10000 | 50 | 12 | .05 | 25 | 12 | 100 | 10000 | 100 | SOD |
| CER670 | 1 | Si | 50 | 50 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 50 | 100 | SOD |
| CER670A | 1 | Si | 50 | 50 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 50 | 100 | SOD |
| CER670B | 1 | Si | 50 | 50 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 50 | 100 | SOD |
| CER680 | 1 | Si | 100 | 100 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 100 | 100 | SOD |
| CER680A | 1 | Si | 100 | 100 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 100 | 100 | SOD |
| CER680B | 1 | Si | 100 | 100 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 100 | 100 | SOD |
| CER690 | 1 | Si | 200 | 200 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 200 | 100 | SOD |
| CER690A | 1 | Si | 200 | 200 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 200 | 100 | SOD |
| CER690B | 1 | Si | 200 | 200 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 200 | 100 | SOD |
| CER700 | 1 | Si | 400 | 400 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 400 | 100 | SOD |
| CER700A | 1 | Si | 400 | 400 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 400 | 100 | SOD |
| CER700B | 1 | Si | 400 | 400 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 400 | 100 | SOD |
| CER710 | 1 | Si | 600 | 600 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 600 | 100 | SOD |
| CER710A | 1 | Si | 600 | 600 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 600 | 100 | SOD |
| CER710B | 1 | Si | 600 | 600 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 600 | 100 | SOD |
| CER720 | 1 | Si | 800 | 800 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 800 | 100 | SOD |
| CER720A | 1 | Si | 800 | 800 | 75 | 1.2 | .075 | 25 | 1.2 | 50 | 800 | 100 | SOD |
| CER720B | 1 | Si | 800 | 800 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 800 | 100 | SOD |
| CER720C | 1 | Si | 800 | 800 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 800 | 100 | SOD |
| CER730 | 1 | Si | 1000 | 1000 | 750 | 1.2 | .75 | 25 | 1.2 | 50 | 1000 | 100 | SOD |
| CER730A | 1 | Si | 1000 | 1000 | 75 | 1.2 | .075 | 25 | 1.2 | 50 | 1000 | 100 | SOD |
| CER730B | 1 | Si | 1000 | 1000 | 150 | 1.2 | .15 | 25 | 1.2 | 50 | 1000 | 100 | SOD |
| CER730C | 1 | Si | 1000 | 1000 | 250 | 1.2 | .25 | 25 | 1.2 | 50 | 1000 | 100 | SOD |
| CR4.021A | 5 | Si | 25 | | | | 4.0 | 25A | | | | | AEI |
| CR4.051A | 5 | Si | 50 | | | | 4.0 | 25A | | | | | AEI |
| CR4.071A | 5 | Si | 75 | | | | 4.0 | 25A | | | | | AEI |
| CR4.101A | 5 | Si | 100 | | | | 4.0 | 25A | | | | | AEI |
| CR4.151A | 5 | Si | 150 | | | | 4.0 | 25A | | | | | AEI |
| CR4.201A | 5 | Si | 200 | | | | 4.0 | 25A | | | | | AEI |
| CR4.251A | 5 | Si | 250 | | | | 4.0 | 25A | | | | | AEI |
| CR4.301A | 5 | Si | 300 | | | | 4.0 | 25A | | | | | AEI |
| CR8.021A | 5 | Si | 25 | | | | 8.0 | 25A | | | | | AEI |
| CR8.051A | 5 | Si | 50 | | | | 8.0 | 25A | | | | | AEI |
| CR8.071A | 5 | Si | 75 | | | | 8.0 | 25A | | | | | AEI |
| CR8.101A | 5 | Si | 100 | | | | 8.0 | 25A | | | | | AEI |
| CR8.151A | 5 | Si | 150 | | | | 8.0 | 25A | | | | | AEI |
| CR8.201A | 5 | Si | 200 | | | | 8.0 | 25A | | | | | AEI |
| CR8.251A | 5 | Si | 250 | | | | 8.0 | 25A | | | | | AEI |
| CR8.301A | 5 | Si | 300 | | | | 8.0 | 25A | | | | | AEI |
| DR100 | 1 | Si | 100 | | | | .50 | 25 | 1.0 | 100 | 100 | 100 | DES |
| DR200 | 1 | Si | 200 | | | | .50 | 25 | 1.0 | 100 | 200 | 100 | DES |
| DR300 | 1 | Si | 300 | | | | .50 | 25 | 1.0 | 100 | 300 | 100 | DES |
| DR400 | 1 | Si | 400 | | | | .50 | 25 | 1.0 | 100 | 400 | 100 | DES |
| DR500 | 1 | Si | 500 | | | | .50 | 25 | 1.0 | 100 | 500 | 100 | DES |
| DR600 | 1 | Si | 600 | | | | .50 | 25 | 1.0 | 100 | 600 | 100 | DES |
| DR700 | 1 | Si | 700 | | | | .50 | 25 | 1.0 | 100 | 700 | 100 | DES |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HC70 | 1 | Si | 400 | 400 | 200 | 1.2 | 1.10 | 25 | 1.2 | 400 | 400 | 100 | SOD |
| HC69 | 1 | Si | 200 | 200 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 200 | 200 | 100 | SOD |
| HC68 | 1 | Si | 100 | 100 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 100 | 100 | 100 | SOD |
| HC67 | 1 | Si | 50 | 50 | 1100 | 1.2 | 1.10 | 25 | 1.2 | 50 | 100 | 100 | SOD |
| PD300 | 1 | Si | 150 | 125 | 200 | 1.0 | 4.0 | 25 | | | | | PSC |
| DR1200 | 1 | Si | 1200 | | | | .50 | 25 | 1.0 | 100 | 1200 | 100 | DES |
| DR1100 | 1 | Si | 1100 | | | | .50 | 25 | 1.0 | 100 | 1100 | 100 | DES |
| DR1000 | 1 | Si | 1000 | | | | .50 | 25 | 1.0 | 100 | 1000 | 100 | DES |
| DR900 | 1 | Si | 900 | | | | .50 | 25 | 1.0 | 100 | 900 | 100 | DES |
| DR800 | 1 | Si | 800 | | | | .50 | 25 | 1.0 | 100 | 800 | 100 | DES |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VA713B | 2 | Ge | 140 | 140 | | | | 13 | 35A | .50 | 50ma | 140 | 65J | EEVB-6 |
| VA713C | 2 | Ge | 120 | 120 | | | | 13 | 35A | .50 | 50ma | 120 | 65J | EEVB-6 |
| VA719A | 2 | Ge | 160 | 160 | | | | 20 | 35A | .50 | 50ma | 160 | 65J | EEVB-6 |
| VA719B | 2 | Ge | 140 | 140 | | | | 20 | 35A | .50 | 50ma | 140 | 65J | EEVB-6 |
| VA719C | 2 | Ge | 120 | 120 | | | | 20 | 35A | .50 | 50ma | 120 | 65J | EEVB-6 |

UNDER USE
1 - General Purpose
2 - Power Rectifier
3 - Magnetic Amplifier
5 - Controlled Rectifier
6 - Dual Rectifier
7 - Controlled Forward Conductance

OTHER
4 - For half wave resistance lead average over 1 cycle

REVERSE CURRENT
☑ - Dynamic

MFR
6 - Available in Stack form from Mfr.

8 - High Voltage Rectifier
9 - Bridge Rectifier
☑ - Revised Specifications
Ø - Insulated Base
△ - Direct Tube Replacement
† - Pair
# - Forced Air Cooling

FOLLOWING ANY TEMPERATURE READING
A - Ambient
C - Case
J - Junction
S - Storage
△ - Inlet temperature of coolant

## CHARACTERISTICS CHART of SILICON ZENER or AVALANCHE DIODES

| TYPE NO. | Zener or Avalanche Voltage Range | | | Dynamic Impedance | | MAX. DISS. | TEMP. CO-EFFICIENT | MFR. (See code at start of chart) |
|---|---|---|---|---|---|---|---|---|
| | MIN. $E_{b1}$ (volts) | MAX. $E_{b2}$ (volts) | @ $I_z$ (ma) | Z @ $I_z$ (ohms) | (ma) | (mw) | %/°C | |
| 3/4T5A11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .0005max. | DIC |
| 3/4T5B11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .0005max. | DIC |
| 3/4T5C11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .0005max. | DIC |
| 3/4T10A11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .001max. | DIC |
| 3/4T10B11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .001max. | DIC |
| 3/4T10C11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .001max. | DIC |
| 3/4T20A11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .002max. | DIC |
| 3/4T20B11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .002max. | DIC |
| 3/4T20C11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .002max. | DIC |
| 3/4T50A11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .005max. | DIC |
| 3/4T50B11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .005max. | DIC |
| 3/4T50C11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .005max. | DIC |
| 3/4T100A11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .01max. | DIC |
| 3/4T100B11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .01max. | DIC |
| 3/4T100C11.7 | 11.2 | 12.2 | 7.5 | 25 | 7.5 | 750 | .01max. | DIC |
| 1C9.1Z | 8.2 | 10 | 50 | 3.0 | 50 | 1000 | | ESP |
| 1C10Z | 9.0 | 11 | 50 | 3.5 | 50 | 1000 | | ESP |
| 1C11Z | 9.9 | 12.1 | 50 | 4.2 | 50 | 1000 | | ESP |
| 1C12Z | 10.8 | 13.2 | 50 | 5.0 | 50 | 1000 | | ESP |
| 1C13Z | 11.7 | 14.3 | 50 | 5.8 | 50 | 1000 | | ESP |
| 1C15Z | 13.5 | 16.5 | 50 | 7.6 | 50 | 1000 | | ESP |
| 1C16Z | 14.4 | 17.6 | 50 | 8.6 | 50 | 1000 | | ESP |
| 1C18Z | 16.2 | 19.8 | 50 | 11 | 50 | 1000 | | ESP |
| 1C20Z | 18 | 22 | 15 | 13 | 15 | 1000 | | ESP |
| 1C22Z | 19.8 | 24.2 | 15 | 16 | 15 | 1000 | | ESP |
| 1C24Z | 21.6 | 26.4 | 15 | 18 | 15 | 1000 | | ESP |
| 1C27Z | 24.3 | 29.7 | 15 | 23 | 15 | 1000 | | ESP |
| 1C30Z | 27 | 33 | 15 | 28 | 15 | 1000 | | ESP |
| 1C33Z | 29.7 | 36.3 | 15 | 33 | 15 | 1000 | | ESP |
| 1C36Z | 32.4 | 39.6 | 15 | 39 | 15 | 1000 | | ESP |
| 1C39Z | 35.1 | 42.9 | 15 | 45 | 15 | 1000 | | ESP |
| 1C43Z | 38.7 | 47.3 | 15 | 54 | 15 | 1000 | | ESP |
| 1C47Z | 42.3 | 51.7 | 15 | 64 | 15 | 1000 | | ESP |
| 1C51Z | 45.9 | 56.1 | 15 | 74 | 15 | 1000 | | ESP |
| 1C56Z | 50.4 | 61.6 | 15 | 88 | 15 | 1000 | | ESP |

## CHARACTERISTICS CHART of SILICON ZENER or AVALANCHE DIODES

| TYPE NO. | Zener or Avalanche Voltage Range MIN. $E_{b1}$ (volts) | MAX. $E_{b2}$ (volts) | @ $I_z$ (ma) | Dynamic Impedance Z @ $I_z$ (ohms) | (ma) | MAX. DISS. (mw) | TEMP. CO-EFFICIENT %/°C | MFR. (See code at start of chart) |
|---|---|---|---|---|---|---|---|---|
| 1C62Z | 55.8 | 68.2 | 5.0 | 105 | 5.0 | 1000 | | ESP |
| 1C68Z | 61.2 | 74.8 | 5.0 | 125 | 5.0 | 1000 | | ESP |
| 1C75Z | 67.5 | 82.5 | 5.0 | 150 | 5.0 | 1000 | | ESP |
| 1C82Z | 73.8 | 90.2 | 5.0 | 175 | 5.0 | 1000 | | ESP |
| 1C91Z | 81.9 | 100 | 5.0 | 220 | 5.0 | 1000 | | ESP |
| 1C100Z | 90 | 110 | 5.0 | 260 | 5.0 | 1000 | | ESP |
| 1C110Z | 99 | 121 | 5.0 | 320 | 5.0 | 1000 | | ESP |
| 1C120Z | 108 | 132 | 5.0 | 390 | 5.0 | 1000 | | ESP |
| 1C130Z | 117 | 143 | 5.0 | 450 | 5.0 | 1000 | | ESP |
| 1C150Z | 135 | 165 | 5.0 | 600 | 5.0 | 1000 | | ESP |
| 1C160Z | 144 | 176 | 5.0 | 700 | 5.0 | 1000 | | ESP |
| 1C180Z | 162 | 198 | 5.0 | 900 | 5.0 | 1000 | | ESP |
| 1C200Z | 180 | 220 | 5.0 | 1100 | 5.0 | 1000 | | ESP |
| 1N3148 | 8.1 | 8.9 | 10 | 15 | 10 | 400 | .005 | WEC |
| HR2.3 | 2.18 | 2.41 | 5.0 | 60 | 10 | 500 | | HSD |
| HR2.8 | 2.66 | 2.94 | 5.0 | 60 | 10 | 500 | | HSD |
| HR3.8 | 3.61 | 3.99 | 5.0 | 55 | 10 | 500 | | HSD |
| HR4.4 | 4.18 | 4.62 | 5.0 | 45 | 10 | 500 | | HSD |
| HR5.4 | 5.15 | 5.85 | 5.0 | 20 | 10 | 500 | | HSD |
| HR6.5 | 6.17 | 6.83 | 5.0 | 10 | 10 | 500 | | HSD |
| HR9.0 | 8.55 | 9.45 | 5.0 | 20 | 10 | 500 | | HSD |
| HR11 | 10.45 | 11.55 | 5.0 | 30 | 10 | 500 | | HSD |
| HS1 | .58 | .70 | 1.0 | 60 | 1.0 | 250 | .002 | HSD |
| HS2 | .50 | .61 | 1.0 | 60 | 1.0 | 250 | .002 | HSD |
| HS3 | .61 | .75 | 1.0 | 60 | 1.0 | 200 | .002 | HSD |
| HS4 | .49 | .63 | 1.0 | 1.5 | 100 | 1000 | .002 | HSD |
| HS5 | .49 | .63 | 1.0 | 1.5 | 100 | 10000 | .002 | HSD |
| MR33H | 3.1 | 3.5 | 5.0 | 90 | 5.0 | 210 | | AEI |
| MR36H | 3.4 | 3.8 | 5.0 | 86 | 5.0 | 210 | | AEI |
| MR39H | 3.7 | 4.1 | 5.0 | 80 | 5.0 | 210 | | AEI |
| MR43H | 4.0 | 4.5 | 5.0 | 72 | 5.0 | 210 | | AEI |
| MR47H | 4.4 | 5.0 | 5.0 | 62 | 5.0 | 210 | | AEI |
| MR51H | 4.8 | 5.4 | 5.0 | 50 | 5.0 | 210 | | AEI |
| MR56H | 5.3 | 6.0 | 5.0 | 28 | 5.0 | 210 | | AEI |
| MR62H | 5.8 | 6.6 | 5.0 | 10 | 5.0 | 210 | | AEI |
| MR68H | 6.4 | 7.2 | 5.0 | 3.7 | 5.0 | 210 | | AEI |
| MR75H | 7.1 | 7.9 | 5.0 | 4.0 | 5.0 | 210 | | AEI |
| MR82H | 7.7 | 8.7 | 5.0 | 5.5 | 5.0 | 210 | | AEI |
| MR91H | 8.6 | 9.6 | 5.0 | 8.0 | 5.0 | 210 | | AEI |
| MR100H | 9.4 | 10.6 | 5.0 | 11 | 5.0 | 210 | | AEI |
| SS9.1Z ☑ | 8.2 | 10 | 35 | 5.0 | 35 | 750 | | ESP |
| SS10Z ☑ | 9.0 | 11 | 35 | 5.5 | 35 | 750 | | ESP |
| SS11Z ☑ | 9.9 | 12.1 | 35 | 6.0 | 35 | 750 | | ESP |
| SS12Z ☑ | 10.8 | 13.2 | 35 | 7.0 | 35 | 750 | | ESP |
| SS13Z ☑ | 11.7 | 14.3 | 35 | 8.0 | 35 | 750 | | ESP |
| SS15Z ☑ | 13.5 | 16.5 | 35 | 9.0 | 35 | 750 | | ESP |
| SS16Z ☑ | 14.4 | 17.6 | 35 | 11 | 35 | 750 | | ESP |
| SS18Z ☑ | 16.2 | 19.8 | 35 | 14 | 35 | 750 | | ESP |
| SS20Z ☑ | 18 | 22 | 12 | 16 | 12 | 750 | | ESP |
| SS22Z ☑ | 19.8 | 24.2 | 12 | 20 | 12 | 750 | | ESP |
| SS24Z ☑ | 21.6 | 26.4 | 12 | 23 | 12 | 750 | | ESP |
| SS27Z ☑ | 24.3 | 29.7 | 12 | 25 | 12 | 750 | | ESP |
| SS30Z ☑ | 27 | 33 | 12 | 30 | 12 | 750 | | ESP |
| SS33Z ☑ | 29.7 | 36.3 | 12 | 37 | 12 | 750 | | ESP |
| SS36Z ☑ | 32.4 | 39.7 | 12 | 49 | 12 | 750 | | ESP |
| SS39Z ☑ | 35.1 | 42.9 | 12 | 57 | 12 | 750 | | ESP |
| SS43Z ☑ | 38.7 | 47.3 | 12 | 69 | 12 | 750 | | ESP |
| SS47Z ☑ | 42.3 | 51.7 | 12 | 74 | 12 | 750 | | ESP |
| SS51Z ☑ | 45.9 | 56.1 | 12 | 91 | 12 | 750 | | ESP |
| SS56Z ☑ | 50.4 | 61.6 | 12 | 108 | 12 | 750 | | ESP |
| SS62Z ☑ | 55.8 | 68.2 | 5.0 | 135 | 5.0 | 750 | | ESP |
| SS68Z ☑ | 61.2 | 74.8 | 5.0 | 155 | 5.0 | 750 | | ESP |
| SS75Z ☑ | 67.5 | 82.5 | 5.0 | 180 | 5.0 | 750 | | ESP |
| SS82Z ☑ | 73.8 | 90.2 | 5.0 | 215 | 5.0 | 750 | | ESP |
| SS91Z ☑ | 81.9 | 100 | 5.0 | 260 | 5.0 | 750 | | ESP |

## VOLTAGE VARIABLE CAPACITOR DIODES

| TYPE NO. | CAPACITANCE C @ Eb (uuf) | (volts) | PIV | Q @ FREQ. Min. Q | (mc) | MFR. |
|---|---|---|---|---|---|---|
| 1SV120 | 35 | 4.0 | 20 | 35 | 50 | SGSI |
| 1SV130 | 35 | 4.0 | 30 | 35 | 50 | SGSI |
| BA410/C7 | 7.0 | 4.0 | 30 | 50 | 50 | TKD |
| BA410/C10 | 10 | 4.0 | 30 | 50 | 50 | TKD |
| BA410/C15 | 15 | 4.0 | 30 | 50 | 50 | TKD |
| BA410/C20 | 20 | 4.0 | 30 | 50 | 50 | TKD |

UNDER TYPE NO.
∅ - Ceramic Crystal Cartridge
△ - Double Ended Varactor
* - Sub Miniature Ceramic
† - Sub Miniature Glass
☑ - Miniature Pill Varactor

UNDER Q
☑ - Typical

## CHARACTERISTICS CHART of MISCELLANEOUS DIODE TYPES

| TYPE NO. | CLASSIFICATION | DESCRIPTION | MFR. |
|---|---|---|---|
| 1N3152 | 1 | UHF Strip-Line Parametric Amp. | WEC |
| 1N3153 | 1 | UHF Strip-Line Parametric Amp. | WEC |
| 1N3192 | 12 | 5.8A (Pulse) Blow-Out Diode | WEC |
| 1N3205 | 1 | Microwave Mixer (Ku-band) | SYL |
| 1N3205R | 1 | Microwave Mixer (Ku-band) | SYL |
| 46P1 | M | IF min. 2.75ma at 1V; IR máx. .20ma at 50V Conv. Eff. at 30Mc-55 pct. min. | CDLF |
| BTZ10 | 8 | Si; VF - 50V; PRV- 50V; IF -15A nom. | AEG |
| BTZ11 | 8 | Si; VF -100V; PRV-100V; IF -15A nom. | AEG |
| BTZ12 | 8 | Si; VF -200V; PRV-200V; IF -15A nom. | AEG |
| BTZ13 | 8 | Si; VF -350V; PRV-350V; IF -15A nom. | AEG |
| FA2000 | M | Pair Matched to within 10mv at IF-500ua; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA2001 | M | Pair Matched to within 15mv at IF-2ma; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA2002 | M | Pair Matched to within 20mv at IF-5ma; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA2003 | M | Pair Matched to within 10mv at IF-500ua; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA2004 | M | Pair Matched to within 15mv at IF-2ma; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA2005 | M | Pair Matched to within 20mv at IF-5ma; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA2006 | M | Pair Matched to within 30mv at IF-10ma; IF-50ma at 1V;IR-.10ua at 50V; PIV-75V. | FSC |
| FA2007 | M | Pair Matched to within 50mv at IF-25ma; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA2008 | M | Pair Matched to within 10mv at IF-10ua; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA2009 | M | Pair Matched to within 10mv at IF-150ua; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA2010 | M | Pair Matched to within 10mv at IF-10ua; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA2011 | M | Pair Matched to within 10mv at IF-150ua; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA4000 | M | Quad Matched to within 10mv at IF-500ua; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA4001 | M | Quad Matched to within 15mv at IF-2ma; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA4002 | M | Quad Matched to within 20mv at IF-5ma; | FSC |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SS130Z ☑ | 117 | 143 | 5.0 | 550 | 5.0 | 750 | | ESP |
| SS150Z ☑ | 135 | 165 | 5.0 | 730 | 5.0 | 750 | | ESP |
| SS160Z ☑ | 144 | 176 | 5.0 | 820 | 5.0 | 750 | | ESP |
| SS180Z ☑ | 162 | 198 | 5.0 | 1050 | 5.0 | 750 | | ESP |
| SS200Z ☑ | 180 | 220 | 5.0 | 1200 | 5.0 | 750 | | ESP |

UNDER TYPE NO.

☑ - Revised Specifications
Ø - Double Anode Type
* - Developmental Type
Δ - Also available with ±5 per cent tolerance
† - Reference Amplifier
# - Available with reverse polarity

## SWITCHING DIODES

| TYPE NO. | MAT | PIV (volts) | MAX. CONT. REV. WORK. VOLT. (volts) | Min. Forward Current @ 25°C $I_f$ (mA) | @ $E_f$ (volts) | MAX. REVERSE CURRENT @ 25°C $I_b$ (μa) | @ $E_b$ (volts) | Recovery Characteristics: TEST CONDITIONS Fwd. $I_f$ (ma) | Rev. to $E_b$ (volts) | $Z_{rec}$ @ time (t) (K ohms) | (usec) | MFR. See code at start of charts |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1N2791 | Si | | 350 | 50 | 1.3 | .012 | 200 | 10 | 10 | | 4.0 | WEC |
| DB100 | Si | 40 | | 10 | 1.0 | .10 | 30 | 10 | 6.0 | 6.0 | .004 | DES |
| DB110 | Si | 40 | | 20 | 1.0 | .10 | 30 | 10 | 6.0 | 6.0 | .004 | DES |
| DB120 | Si | 100 | | 100 | 1.0 | .10 | 75 | 10 | 6.0 | 6.0 | .003 | DES |
| DK10 | Ge | 25 | | 70 | 1.0 | 10 | 25 | | | | | STCB |
| DK11 | Ge | 60 | | 50 | 1.0 | 35 | 60 | | | | | STCB |
| DK12 | Ge | 100 | | 50 | 1.0 | 60 | 100 | | | | | STCB |
| DW100 | Si | 40 | | 400 | 1.0 | .10 | 30 | 30 | 35 | 400 | .30 | DES |
| DW110 | Si | 100 | | 400 | 1.0 | .10 | 75 | 30 | 35 | 400 | .30 | DES |
| DW200 | Si | 150 | | 400 | 1.0 | .10 | 125 | 30 | 35 | 400 | .30 | DES |
| DW210 | Si | 200 | | 400 | 1.0 | .10 | 175 | 30 | 35 | 400 | .30 | DES |
| DW300 | Si | 235 | | 400 | 1.0 | .20 | 175 | 30 | 35 | 400 | .30 | DES |
| DW310 | Si | 275 | | 400 | 1.0 | .20 | 225 | 30 | 35 | 400 | .30 | DES |
| EW99 | Ge | 15 | 15 | 10 | .40 | 20 | 15 | 10 | 10 | | 5.0mu | GECB |
| FD192 | Si | 30 | 20 | 10 | 1.0 | .10 | 20 | 10 | 6.0 | 6.0 | .002 | FSC |
| FD400 | Si | 100 | 75 | 150 | 1.0 | .10 | 75 | 10 | 6.0 | 4.0 | .075 | FSC |
| GEX943 | Ge | 50 | 50 | 30 | .65 | 5.0 | 50 | 10 | 5.0 | | .20 | GECB |
| GEX944 | Ge | 50 | 50 | 30 | .65 | 5.0 | 50 | 10 | 5.0 | | .20 | GECB |
| GEX945 | Ge | 25 | 25 | 30 | .65 | 4.0 | 25 | 10 | 5.0 | | .20 | GECB |
| GEX946 | Ge | 25 | 25 | 30 | .65 | 4.0 | 25 | 10 | 5.0 | | .20 | GECB |
| TI2 | Si | | 40 | 10 | 1.0 | .025 | 10 | | | | | TII |
| TI6 | Si | | 20 | 5.0 | 1.0 | 1.0 | 10 | | | | | TII |

| | | | |
|---|---|---|---|
| FA4005 | M | Quad Matched to within 20mv at IF-5ma; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA4006 | M | Quad Matched to within 30mv at IF-10ma; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA4007 | M | Quad Matched to within 50mv at IF-25ma; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA4008 | M | Quad Matched to within 10mv at IF-10ua; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA4009 | M | Quad Matched to within 10mv at IF-150ua; IF-10ma at 1V; IR-.10ua at 20V; PIV-30V. | FSC |
| FA4010 | M | Quad Matched to within 10mv at IF-10ua; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| FA4011 | M | Quad Matched to within 10mv at IF-150ua; IF-50ma at 1V; IR-.10ua at 50V; PIV-75V. | FSC |
| JK9A | 10 | Ge.; Ip-.90ma min.; Ip/Iv-2.0 min.; C-25pF Vp-45mv; Vv-170mv; fr-540Mc/s. | STCB |
| JK10A | 10 | Ge.; Ip-4.5ma min.; Ip/Iv-2.0 min.; C-50pF Vp-50mv; Vv-150mv; fr-810Mc/s. | STCB |
| JK11A | 10 | Ge.; Ip-13.5ma min.; Ip/Iv-2.0 min.; C-125pF Vp-55mv; Vv-270mv; fr-810Mc/s. | STCB |
| JK19A | 10 | Ge.; Ip-.90ma min.; Ip/Iv-5.0 min.; C-10pF Vp-55mv; Vv-290mv; fr-1200Mc/s. | STCB |
| JK20A | 10 | Ge.; Ip-4.5mv min.; Ip/Iv-5.0 min.; C-40pF Vp-55mv; Vv-300mv; fr-880Mc/s. | STCB |
| JK21A | 10 | Ge.; Ip-13.5ma min.; Ip/Iv-5.0 min.; C-80pF Vp-55mv; Vv-310mv; fr-1100Mc/s. | STCB |
| JK100A | UNI-TUNNEL | Ge.; Ip-5.0ma min.; Ir-10ua typ; 200mV | STCB |
| KV1 | M | IF-50ma max. at 25 deg.C; IR-100ua at 5V Temp.Coeff-2.3mV/deg.C; VF-135MV at 1.2 ma | KOKJ |
| KV2 | M | IF-50ma max. at 25 deg.C; IR-100ua at 5V Temp.Coeff-2.3mV/deg.C; VF-155MV at 1.2 ma | KOKJ |
| PR4 | 4 | CdS; Va-110V max. | NPC |
| PR5 | 4 | CdS; Va-250V max. | NPC |
| PR7 | 4 | CdS; Va-200V max. | NPC |
| SFD104 | 2 | PIV-25V; Rev. I-6.0ua at 2V. Video Detector | CSF |
| SFD111 | 2 | FM discriminator and ratio detector, matched pair of SFD104. | CSF |
| SFD115 | 2 | FM discriminator and ratio detector, matched pair of SFD110. | CSF |
| SFD117 | 2 | 10dB Avg. NF; PIV-2V; 25ma avg. DC current | CSF |
| SVC16 | 1,3 | Si.; fc-75KMc/s; For use in parametric amplifiers and freq. multipliers. | GECB |
| SVC17 | 1,3 | Si.; fc-85KMc/s; For use in parametric amplifiers and freq. multipliers. | GECB |
| TP5 | 4 | Ge.; Dark I-.10ua max. at 25 deg.C; fco-30Kc | NPC |

UNDER CLASSIFICATION

1 - Microwave Diodes
2 - Mixer or Detector Diodes
3 - Variable Capacitator Diodes
4 - Photodiodes
5 - Solar Cells
6 - Harmonic Generator Diodes
7 - 4-Layer Bistable Diodes
8 - Controlled Rectifier
9 - PNPN Switching Diode
10 - Tunnel Diode
11 - Photoconductive Cell
M - Other Miscellaneous Types

## PREVIOUSLY REGISTERED NEWLY ANNOUNCED DIODES

AMERICAN SEMICONDUCTOR:
1N483B, 1N485B, 1N486B, 1N1124A, 1N1126A, 1N1128A, 1N1771 thru 1N1802, 1N1816A thru 1N1836A

BENDIX:
1N1124, 1N1125, 1N1126, 1N1127, 1N1128, 1N1241 thru 1N1248, 1N1551 thru 1N1557

BRITTON ELECTRONICS:
1N248, 1N248A, 1N248B, 1N249, 1N249A, 1N249B, 1N250, 1N250A, 1N250B, 1N253 thru 1N256, 1N316 thru 1N320, 1N323 thru 1N327, 1N316A thru 1N329A, 1N332 thru 1N349, 1N359 thru 1N363, 1N359A thru 1N365A, 1N440 thru 1N445, 1N440B thru 1N445B, 1N530 thru 1N540, 1N547 thru 1N555, 1N560 thru 1N563, 1N599 thru 1N614, 1N599A thru 1N614A, 1N1095, 1N1096, 1N1100 thru 1N1105, 1N1115 thru 1N1130, 1N1134 thru 1N1138, 1N1169, 1N1183 thru 1N1206, 1N1183A thru 1N1186A, 1N1191A thru 1N1194A, 1N1199A thru 1N1206A, 1N1217 thru 1N1236, 1N1217A thru 1N1224A, 1N1227A thru 1N1234A, 1N1241 thru 1N1248, 1N1341A thru 1N1348A, 1N1434 thru 1N1438, 1N1443, 1N444, 1N1487 thru 1N1493, 1N1537 thru 1N1544, 1N1581 thru 1N1587, 1N1612 thru 1N1616, 1N1692 thru 1N1697, 1N1763, 1N1764, 1N2080 thru 1N2086, 1N2154 thru 1N2160, 1N2218 thru 1N2293, 1N2222A thru 1N2265A, 1N2289A thru 1N2293A, 1N2367 thru 1N2371, 1N2362A thru 1N2371A, 1N2362B thru 1N2371B, 1N2793 thru 1N2798, 1N2858 thru 1N2864

COLUMBUS ELECTRONICS:
1N1487, 1N1488, 1N1489, 1N1490, 1N1491, 1N1492, 1N1692 thru 1N1697

ESPEY ELECTRONICS:
1N253 thru 1N256, 1N536 thru 1N540, 1N547, 1N562, 1N563, 1N712 thru 1N745, 1N1095, 1N1183 thru 1N1198, 1N1351 thru 1N1375, 1N1763, 1N1764, 1N1808 thru 1N1815

FANSTEEL METALLURGICAL:
1N1518, 1N1519, 1N1520, 1N1521, 1N1522, 1N1523, 1N1524, 1N1525, 1N1526, 1N1527, 1N1528, 1N1599 thru 1N1609

MISTRAL:
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MOTOROLA SEMICONDUCTOR:
1N821, 1N823, 1N825, 1N827, 1N1169, 1N1225, 1N1226

PACIFIC SEMICONDUCTORS:
1N430, 1N430A

SEMI-ELEMENTS:
1N316 thru 1N320, 1N319A, 1N320A, 1N322A, 1N323 thru 1N327, 1N323A, 1N326A, 1N327A, 1N329A, 1N359 thru 1N363, 1N362A thru 1N365A, 1N440, 1N440B, 1N441, 1N441B, 1N443, 1N443B, 1N444, 1N444B, 1N531, 1N536 thru 1N540, 1N550, 1N553, 1N553, 1N554, 1N676 thru 1N679, 1N681 thru 1N687, 1N689, 1N1028 thru 1N1033, 1N1081 thru 1N1084, 1N1095, 1N1096, 1N1108, 1N1169, 1N1169A, 1N1251 thru 1N1255, 1N1406, 1N1407, 1N1408, 1N1488 thru 1N1493, 1N1644 thru 1N1653, 1N1692 thru 1N1697, 1N1701 thru 1N1708, 1N1763, 1N1764, 1N2089 thru 1N2086, 1N2090 thru 1N2096, 1N2103 thru 1N2108, 1N2115, 1N2373, 1N2374, 1N2501, 1N2502, 1N2505, 1N2506, 1N2610 thru 1N2615

SYLVANIA:
1N902, 1N903, 1N904, 1N905, 1N906, 1N907, 1N908, 1N914, 1N916

TEXAS INSTRUMENTS:
1N332 thru 1N349, 1N440B thru 1N445B, 1N530 thru 1N535, 1N550 thru 1N555, 1N599 thru 1N606, 1N599A thru 1N606A, 1N607 thru 1N614, 1N607A thru 1N614A, 1N1100 thru 1N1105, 1N1115 thru 1N1120, 1N1124A thru 1N1128A, 1N1487 thru 1N1492, 1N1692 thru 1N1697

UNITRODE:
1N461 thru 1N464, 1N461A thru 1N464A, 1N482 thru 1N485, 1N536 thru 1N540, 1N547, 1N645 thru 1N649, 1N676 thru 1N679, 1N681 thru 1N687, 1N689, 1N1095, 1N1096

SOCIETE INDUCTRIAL DE LIAISONS:
1N538, 1N540, 1N547

TRANS-SIL:
1N246, 1N248A, 1N249, 1N249A, 1N250, 1N250A, 1N253 thru 1N256, 1N332 thru 1N349, 1N550 thru 1N555, 1N607 thru 1N614, 1N607A thru 1N614A, 1N1115 thru 1N1120, 1N1124 thru 1N1128, 1N1183 thru 1N1190, 1N1237 thru 1N1248, 1N1301, 1N1303, 1N1304, 1N1306, 1N1434 thru 1N1438, 1N1581 thru 1N1585, 1N1575 thru 1N1578, 1N1581 thru 1N1587, 1N2109 thru 1N2114, 1N2154 thru 1N2160, 1N2154R thru 1N2160R, 1N2228, 1N2228A, 1N2230, 1N2230A, 1N2232, 1N2232A, 1N2234, 1N2234A, 1N2236, 1N2236A, 1N2238, 1N2238A, 1N2240, 1N2240A, 1N2246, 1N2246A, 1N2248, 1N2248A, 1N2250, 1N2250A, 1N2252, 1N2252A, 1N2254, 1N2254A, 1N2256, 1N2256A, 1N2258, 1N2258A, 1N2260, 1N2260A, 1N2272 thru 1N2279, 1N2282 thru 1N2286

U.S. SEMICONDUCTOR:
1N253 thru 1N256, 1N1351A thru 1N1375A, 1N1591A thru 1N1598A, 1N1603A thru 1N1609A, 1N1806A,

# Market

**Sales**

The Marketing Data Department of the Electronic Industries Association has reported a total of 127,928,586 transistors valued at $301,432,285 were sold at the factory during the past year. The year before, 82,294,120 units were sold and revenue accrued totaled $222,009,722. December was 1960's high month for the number of transistors sold with a total of 13,347,525. The December sales value of $27,915,649, however, was the third highest monthly total. EIA's final 1960 figures are shown below:

| | *Factory Sales (Units)* | *Factory Sales (Dollars)* |
|---|---|---|
| December | 13,347,525 | $27,915,649 |
| November | 12,149,077 | 25,372,480 |
| October | 12,168,632 | 25,945,195 |
| September | 12,973,792 | 28,442,229 |
| August | 9,732,993 | 22,739,969 |
| July | 7,070,884 | 18,083,802 |
| June | 10,392,412 | 27,341,733 |
| May | 9,046,237 | 24,146,373 |
| April | 9,891,236 | 23,198,576 |
| March | 12,021,506 | 28,700,129 |
| February | 9,527,662 | 24,831,570 |
| January | 9,606,630 | 24,714,580 |
| Year-end '60 | 127,928,586 | 301,432,285 |
| Year-end '59 | 82,294,120 | 222,009,722 |

The United States Department of Commerce has reported the following figures on Japanese produced semiconductor devices for the first nine months of 1960.

Japanese Electronics Production, 1959 and January-September 1959 and 1960

| | Quantity in thousands of units | | | Value in thousands of dollars | | |
|---|---|---|---|---|---|---|
| | | January-September | | | January-September | |
| Product | 1959 | 1959 | 1960 | 1959 | 1959 | 1960 |
| Semiconductor devices | .... | .... | .... | 52,893 | 37,794 | 55,053 |
| Diodes | 33,094.9 | 22,526.0 | 32,873.0 | 6,963 | 5,150 | 5,412 |
| Germanium | n.s.s. | n.s.s. | 31,891.5 | n.s.s. | n.s.s. | 4,774 |
| Silicon | n.s.s. | n.s.s. | 981.5 | n.s.s. | n.s.s. | 638 |
| Transistors | 86,500.5 | 56,808.1 | 104,377.2 | 44,479 | 31,567 | 42,431 |
| Germanium | n.s.s. | n.s.s. | 104,305.1 | n.s.s. | n.s.s. | 42,257 |
| Silicon | n.s.s. | n.s.s. | 72.1 | n.s.s. | n.s.s. | 174 |
| Photo-transistors | 23.5 | 14.5 | 52.5 | 58 | 42 | 90 |
| Thermistors | 8,677.6 | 6,055.1 | 6,862.0 | 1,393 | 1,035 | 860 |
| Varistors | n.a. | n.a. | 3,626.8 | n.a. | n.a. | 673 |
| Rectifier elements | n.a. | n.a. | 4,671.1 | n.a. | n.a. | 5,587 |
| Germanium | | | 62.0 | | | 173 |
| Silicon | | | 1,021.5 | | | 2,879 |
| Selenium | | | 3,555.7 | | | 2,509 |
| Other | | | 31.9 | | | 26 |

n.a. Not available
n.s.s. Not shown separately.

NOTE: These statistics include only production data from manufacturers employing 20 or more workers.

Western Electric Co., Inc., subsidiary of American Telephone and Telegraph Corp. has established a sales organization to expand activities in its military semiconductor arm. Plans call for the establishment of a West Coast, Midwest and Northeast regional sales engineering offices staffed by sales engineers. This is the first time that any Western Electric division has established a formal sales staff.

Mitsubishi Shoji Kaisha, Ltd., Tokyo, a foreign trading firm, has started the sale in Japan of high-purity silicon single crystals imported from Les Produits Semiconductors of France, a subsidiary of Pechiney.

General Electric Company's Semiconductor Products Department has added a government relations unit to its marketing organization.

Wright Engineering Company, Pasadena, California, has been named sales representative for the line of "Increductor" magnetic components produced by Trak Electronics Company, Inc., Wilton, Connecticut, in a territory which includes the states of Arizona, California, and Nevada.

Rheem Semiconductor Corp., has received military qualification for three of its silicon diodes. The diodes are designated Navy 1N483B, 1N485B, 1N486B and are qualified per Mil-S-19500/118.

RCA has opened a new sales office and engineering building in Los Angeles, Calif., to service West Coast customers of RCA electron tube and semiconductor products. The firm is also expanding its local warehouse building by nearly 40% with the addition of 18,000 square feet to the present warehouse in Los Angeles.

**Prices**

Pacific Semiconductors, Inc., has put into effect a price reduc tion of 40% on their entire line of Micro-and-Pico-transistors Micro-transistor type PMT114 is now $35. Pico-transistor typ PMT011 has been reduced to $20. Type PMT-116 (equivalent 2N705) recently added, has been listed at $45 in lots up to 99. Th firm has also recently reduced prices on its line of general con puter type micro-diodes from 10 to 20%.

Sylvania Electric Products, Inc.'s Semiconductor division ha available two new epitaxial mesa transistors with switching time of 110 nanoseconds. Type 2N781 is priced at $11.72 each in lots u to 99, and at $7.81 each in quantities from 100-999. The 2N782 priced at $10.50 and $7.00 each in similar quantities.

Texas Instruments Inc., has introduced two silicon epitaxia transistors. Their 2N744 is priced at $13.95 each in quantities o 100 to 999, while their 2N743 costs $15.35 in like quantities. Th firm has also announced prices on their new microminiatur glass diodes. In lots of 1-99 their T1-2 is priced at $5 each an their T1-6 at $3.50 each.

Ohio Semiconductors has available a thermoelectric junction array and module all in large quantities. The cost of the singl junction TA-12 in quantities up to 24 is $18.42 each; from 24-99 $14.74; and from 100-999, $12.28. The arrays, each composed o eight junctions are priced at $85.19, $68.15 and $56.79 in simila quantities. The modules also are listed at $91.06, $72.85 and $60.7 in the same quantities.

RCA's Semiconductor division has made available a develop mental 3 watt, 200 mc silicon mesa transistor. This *n-p-i-n* tripl diffused unit is available at $150 each.

Sprague Electric Co. is now producing small signal silico transistors under license from Philco Corp. In quantities of 100 and up the units are each priced as follows: 2N1118, $7.7 2N1118A, $10.50; 2N1119, $7.75; and 2N1429 at $5.85.

Hughes Aircraft Co. has placed thermoelectric junctions on th market. These are priced between $18 and $30 each in prototyp quantities.

GE has announced a 41% price reduction on three industria models of silicon unijunction transistors, types 2N1671, 2N1671 and 2N1671B. The new prices, range from $1.80 each to $2.15 eac in large quantities to original equipment manufacturers.

Dickson Electronics Corp., Scottsdale, Ariz. has available fou Zener diodes. These diffused junction devices are rated at 0.7 1,1.5 and 10w. Prices range from $1.36 to $15.90 each dependin upon wattage, tolerance and quantity.

Fansteel Metallurgical Corp., Rectifier-Capacitor division, Nort Chicago, Ill. has marketed three Si rectifiers rated at 20,35 an 70a. These are priced from $2 to $40 each. The company also ha available two stack assemblies for 20 and 35a rectifiers. They ar priced starting at $10 each.

Rheem Semiconductor Corp. has developed a subminiatur glass-packaged diode 1N658A priced at $4 each; 1-99.

Westinghouse Electric Corp.'s Semiconductor division has intro duced a new line of silicon *n-p-n* transistors with power gai up to 1000. Prices on the WX118U series vary from $87 to $140 quantities from 1 to 24, and $73 to $117 in quantities from 25 100. For WX118X series prices range from $148 to $238 in quantiti up to 24 units, and $124 to $199 from 25 to 100 units.

Pacific Semiconductors, Inc. is manufacturing two new lamina diodes. Their PS7435 is priced at $4.35 each in quantities of 10 999 while the PS7436 is $5 each in the same quantities.

Inland Testing Laboratories, a division of Cook Electric C Morton Grove, Ill. has developed a programmed, automatic tra sistor and diode tester capable of measuring up to 50 componen through 14 test parameters in a single test run. Depending up requirements the unit will cost between $70,000 to $100,000 eac

**Suppliers**

Cominco Products, Inc., Spokane, Wash., wholly owned su sidiary of the Consolidated Mining and Smelting Co. of Canad Ltd. has established a new plant in the Spokane Industrial Pa to produce high purity metals for transistors and other electron equipment.

# News . . .

Texas Instruments Incorporated and International Telephone and Telegraph Corporation recently announced an agreement to exchange non-exclusive patent licenses and technical information concerning semiconductor components. Texas Instruments will also supply a portion of ITT's needs for semiconductor devices and components.

Hughes Aircraft Company's semiconductor division has established a new department for packaged assembly service offering use of any customer-specified components. The new department will offer customers a choice of components from the Hughes line of transistors, capacitors, rectifiers, and diodes, or components made by other manufacturers.

**Distributors**

Tyco Semiconductor Corp., Boston has concluded a contract with the Distributor division of Erie Resistor Corp. for the national distribution of Tyco's line of gallium arsenide varactor diodes, controlled rectifiers and transistors.

Syntron Co., Semiconductor division Homer City, Pa., has named Hilltronics, Inc., Detroit as their representative in that area.

PRL Electronics, Inc., manufacturers of Electronic Power Supplies and Specialized Test Equipment has appointed W. A. Brown and Associates Alexandria, Virginia as their exclusive representatives in the Delaware, Maryland, District of Columbia and Virginia territories.

The Birtcher Corporation's Industrial Division has announced the appointment of Zack Electronics of Palo Alto as a distributor for its line of tube, transistor and component retention and cooling devices in Northern California.

Silicon Transistor Corp., Carle Place, L. I., N. Y., has announced the appointment of Montclair Electronics International, Inc., New York City, as its exporter to France for its line of silicon glass diodes and silicon power transistors.

Bell Electronic Corp., Los Angeles, Calif., West Coast electronic parts and equipment distributor, has increased the product lines it distributes to include tube clamps, transistor clips and heat sinks produced by The Birtcher Corp.

**Financial**

Philco Corp. has reported sales in 1960 of $400,587,000 compared with $397,792,000 the previous year. Net income was $2,287,000 or 47¢ a share against $7,176,000 or $1.67 a share in 1959. This represented an increase in sales of 0.7% but a 68% decrease in earnings. The firms Lansdale Semiconductor division has reported a 45 to 50% increase in sales over 1959.

Temperature Engineering Corp., Riverton, N.J., has had a record year in sales and profits for 1960. Sales were $1,049,607 as against $609,984 in 1959. Net earnings were $72,291 as compared with $44,344 the previous year. This represents a 31.1¢ per share net profit for last year.

Accurate Specialties Corp., Hackensack, N.J., has announced that its earnings for the six months period ending Dec. 31, 1960 more than tripled those of the previous year as sales increased 53%. Net profit was $73,500 equal to 21¢ a share compared with $22,000 or 7¢ in the corresponding period of 1959. Sales were $826,532 against $539,500 for the same period a year earlier.

General Electric Co. has had a 29% decline in net profits and a 3% drop in sales for the year ending Dec. 31, 1960. Net earnings totaled $200,100,000 equal to $2.26 a share. This compares with $289,242,123 or $3.19 a share for 1959. Sales amounted to $4,197,500,000 as against $4,349,508,529 the previous year.

International Resistance Co., Philadelphia has entered the semiconductor field with the purchase of controlling interest in North American Electronics, Inc., Lynn, Mass., manufacturer of more than 600 types of silicon rectifiers and Zener diodes as well as silicon-controlled rectifiers.

Tung-Sol Electric Inc. has had a decline of 45% in earnings and 8% in sales in 1960. Net for the year was $1,476,259 equal to $1.37 a share, compared with $2,712,552 or $2.50 a share in 1959. Total sales declined to $66,471,971 from $72,345,248 the year earlier. The company's earnings were greatly reflected in heavy product development and pilot run costs, especially in transistors and silicon diodes.

Sprague Electric Company, North Adams, Massachusetts, has declared a quarterly dividend of 30 cents per share on the Company's common stock.

Merck & Co., Inc. and consolidated subsidiaries has reported net sales in 1960 of $218,100,000, compared with $216,900,000 in 1959. Estimated net income after taxes was $27,800,000 in 1960, equal to $2.57 per share of common stock outstanding, compared with $30,000,000 or $2.79 per share in 1959.

Trak Electronics Company, Inc., Wilton, Connecticut, has acquired Tucor, Inc., South Norwalk, Conn. Acquisition of Tucor was effected by an exchange of stock. Trak obtained more than 80% of Tucor stock in the transaction.

Sales of Espey Mfg. & Electronics Corp. for the first half of the fiscal year ended December 31, 1960, rose to $2,464,977 from $1,989,648 in the corresponding period the previous year. Net earnings for the six months ended last December 31 amounted to $96,689, equal to 41 cents per common share on the 235,721 shares outstanding at the end of the period. This compares with $93,613 and 40 cents per share in the similar period in 1959. Extraordinary expenses of $85,000 were caused by preparatory costs of the Semiconductor Division; after this deduction, reported income equalled $195,189 before taxes.

Lindly & Company, Inc., Mineola, N. Y., manufacturers of transistorized industrial electronic equipment, reports a 13.3% increase for the year as compared with 1959, despite a poor fourth quarter in 1960. The company has a substantial backlog of orders for proprietary products from both foreign and domestic sources, as well as prime contracts from the U. S. Air Force and Signal Corps for electronic and optical equipment.

Minneapolis-Honeywell Regulator Co. has reported an increase of 11.8% in sales during 1960 and a drop in earnings of 10.8% behind that of 1959. Net for the year totaled $26,228,539 equal to $3.74 a share as against $29,399,399 or $4.20 a share in 1959. Sales amounted to $426,255,682 compared with $381,408,597 a year earlier.

Lafayette Radio Electronics Corp., Jamaica, N. Y. has filed a prospectus covering $2.5 million of debentures and 100,000 outstanding shares of common stock.

Hoffman Electronics Corp. has reported its 1960 sales at $54,-120,000 up 17% over the 1959 figure of $46,359,000. The firm had a net loss for the year of $961,000 as against a profit of $1,990,165 in 1959. The firm's Semiconductor division operated profitably in 1960 on sales in excess of $10 million.

**New Firms**

Electronic Metals and Alloys, Inc., has been established in Watertown, Mass. The firm plans to supply semiconductor manufacturers with alloys, clad materials, cans, alloy dots and whisker materials.

The opening of the Quantum Electronics Laboratories, Santa Ana, California, has been announced by Quantatron, Inc., applied science firm of Santa Monica, California. The new facility is planning research and development on solid-state devices. Specific areas of interest include semiconductors and superconductors, with applications in the fields of computer elements, infrared detectors, generalized switching, and microelectronics.

**Expansion**

Grace Electronic Chemicals, Inc., a subsidiary of W. R. Grace & Co., is planning to expand their bulk silicon plant in Puerto Rico.

Accurate Specialties Co., Inc., Hackensack, N. J. is expecting to establish a three-shift operation and increase their daily output of germanium to 25 kilos. The firm is also planning to set up a laboratory and production facilities for intermetallic compounds, among which will be gallium arsenide as well as lead, zinc, and cadmium teluride for thermoelectric applications.

Temperature Engineering Corporation has started construction on their new million-dollar 35,000 square foot manufacturing plant in Riverton, N. J. This facility, scheduled for completion in June, will triple the firm's capacity.

Sprague Electric Company has consolidated all of its transistor manufacturing, engineering, and marketing activities in a new Transistor Division. The Sprague Transistor Division will have its headquarters at Sprague's Concord, N. H., 60,000 square foot semiconductor plant.

Solid State Materials Corporation of East Natick, Mass., has moved into their new building in East Natick Industrial Park. This building has 3,800 square feet of space on one floor, and houses all facilities for the growing of single crystal materials for solid state electronics, and for the design, development, and construction of crystal growing equipment.

## CONFERENCE CALENDAR

**The Following May 1961 Meetings Are Scheduled:**

May 2- 4 Electronic Components Conference, Jack Tar Hotel, San Francisco, Calif. Sponsored by PGCP, AIEE, EIA, WEMA, IRE. For information: Hugh C. Ross, Jennings Radio Mfg. Corp., POB 1278, San Jose 8, Calif.

May 4- 5 2nd National Symposium on Human Factors in Electronics, Marriott Twin Bridges Motor Hotel, Arlington, Va. Sponsored by PGHFE. For Information: Ezra Krendel, Franklin Institute, Phila., 3, Pa.

May 8- 9 5th Midwest Symposium on Circuit Theory, Allerton Park & Urbana Campus, University of Illinois. Sponsored by PGCT. For Information: Prof. M. E. Van Valkenburg, Dept. of E.E., Univ. of Illinois, Urbana, Ill.

May 9-11 Western Joint Computer Conference (WJCC), Ambassador Hotel, Los Angeles. Sponsored by PGEC, AIEE, ACM. For Information: Prof. Cornelius Leondes, Dept. of E.E., Univ. of Calif., 405 Hilgard Ave., Los Angeles 24, Cal.

May 17-19 Northeast District Meeting AIEE, Statler Hotel, Hartford, Conn.

May 18-19 Electro-Optical & Radiation Devices Symposium, Dabney Hall Lounge, Cal. Inst. of Tech., Pasadena. Sponsored by PGED, AIEE. For Information: Chas. F. Spitzer, General Electric Co., 951 Commercial Street, Palo Alto, Cal.

May 22-24 National Telemetering Conference, Sheraton Towers Hotel, Chicago. Sponsored by PGSET, AIEE, IAS, ARS, ISA. For Information: Jack Becker, AC Spark Plug Div., General Motors, Milwaukee, Wis.

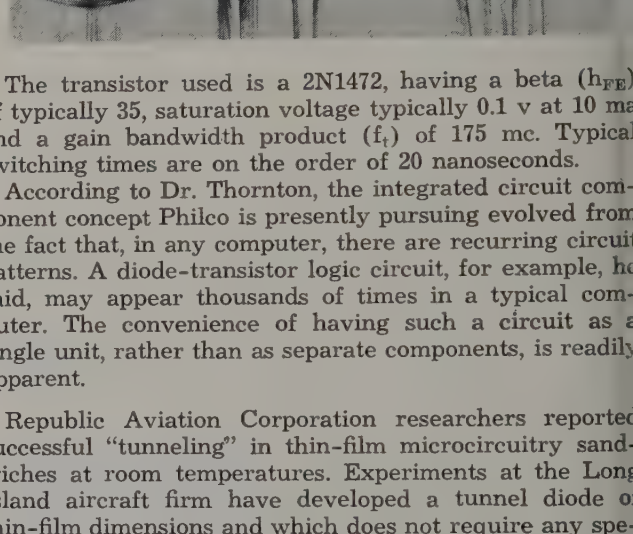
## RESEARCH AND DEVELOPMENT

A laboratory prototype *MADT* transistor has been measured at 5000 mc, maximum frequency of oscillation, at Philco's Lansdale Division. The prototype device was developed by semiconductor research engineers under the guidance of Dr. C. G. Thornton, director of R & D. Dr. Thornton explained that the *MADT* (Micro Alloy Diffused-base Transistor) exhibits a gain of 14 db at 1000 mc and 21 db at 420 mc, with noise figures of 8 db and 4 db respectively. The development promises to greatly increase the usefulness of transistors for ultra-high frequency space communications, particularly in the one to four thousand mc range. Dr. Thornton stated, "The performance level exhibited by this *MADT* has been made possible through careful optimization of electrode geometry." He explained that electrodes of approximately 1½ mils in diameter and a base width of .03 mils have been utilized. These factors, he said, plus an increase in surface concentration in the region immediately adjacent to the edge of the emitter have permitted a 2 to 1 reduction in the level of high frequency base resistance ($r_b1$).

Microelectronics developmental work at Philco's Lansdale Division has resulted in the fabrication of various integrated circuit components, i.e., circuit elements associated with a single function mounted in a single enclosure. Dr. C. G. Thornton, director of semiconductor R & D, explained that silicon diode arrays having a common cathode and silicon transistor-diode logic pacs with

# Industry

fan outs up to five diodes are available in engineering samples. He said that diode arrays of 3 to 8 diodes per pac have been fabricated. The diodes used are low conductance, very fast switching silicon computer devices with reverse recovery switching speeds in the five nanosecond range. Typical characteristics show diode breakdown voltage at 60 volts, .03 ua reverse leakage current and 1.8 uuf capacitance at 0. voltage.



The transistor used is a 2N1472, having a beta ($h_{FE}$) of typically 35, saturation voltage typically 0.1 v at 10 ma and a gain bandwidth product ($f_t$) of 175 mc. Typical switching times are on the order of 20 nanoseconds.

According to Dr. Thornton, the integrated circuit component concept Philco is presently pursuing evolved from the fact that, in any computer, there are recurring circuit patterns. A diode-transistor logic circuit, for example, he said, may appear thousands of times in a typical computer. The convenience of having such a circuit as a single unit, rather than as separate components, is readily apparent.

Republic Aviation Corporation researchers reported successful "tunneling" in thin-film microcircuitry sandwiches at room temperatures. Experiments at the Long Island aircraft firm have developed a tunnel diode of thin-film dimensions and which does not require any special super-cooling to be functional, the company reported. Previous developments in the thin-film areas have uncovered devices similar in function to tunnel diodes but requiring near liquid helium temperatures (about 500° F below zero) to become superconductive. The discovery disclosed by Dr. Franz Huber and Joseph Bloxsom, solid-state physicists at Republic, is expected to greatly simplify extension of the microminiaturization of electronic components. In particular it is said to provide a practical approach to adding the vital diode units to the family of thin-film devices.

Company scientists said they achieved their thin-film sandwich by capturing titanium vapor on a strip of glass to form a dielectric coating, or film. This is done through a special oxidation technique that deposits a film less than one millionth of an inch thick. Although the titanium dioxide film is essentially an insulator, electrons have the ability to pierce or "tunnel" through the extremely thin oxide film, it was explained. The new technique will simplify microminiaturization methods because it eliminates the complicated procedure of incorporating transistors into printed circuits.

Dr. Huber pointed out, however, that a great deal of work still remains to be done, particularly to achieve a higher degree of reliability in the production of thin-film devices. These are now largely experimental, he explained.

# News . . .

## THERMOELECTRICITY

A new group of high-temperature thermoelectric materials, which permit the direct conversion of heat into electricity at temperatures considerably above the melting point of copper, has been developed by scientists of the Westinghouse Electric Corporation. The new thermoelectric materials are varieties of two compounds, samarium sulfide, developed by M. D. Houston, and cerium sulfide, developed by Dr. E. L. Carter. The new compounds are refractory materials and have excellent high-temperature stability and good thermoelectric efficiencies at temperatures as high as 2000° F. Dr. S. W. Herwald, Westinghouse vice president, research, said the new materials resulted from a "continuing research and development program, under sponsorship of the Bureau of Ships, U. S. Navy, for the discovery and practical development of advanced thermoelectric materials."

The two families of rare earth sulfides are prepared in a similar manner, by directly combining the pure metal with sulfur. In the case of samarium sulfide, the samarium and sulfur are heated to high temperatures in a protective atmosphere. The rate of temperature rise, final temperatures, and length of reaction time are carefully controlled. Following the chemical reaction between the samarium and the sulfur, the resulting sulfide is crushed, compacted into cylindrical-shaped pellets, and sintered in a vacuum induction furnace. The composition of the various sulfides which result from the metal-sulfur reaction are determined by X-ray diffraction analysis. Physical, electrical and chemical tests then are run on the completed thermoelectric pellets. The new thermoelectric materials are expected to find application in future thermoelectric power generators. To improve the over-all efficiency of such power generators, several different types of thermoelectric materials are used in series or cascade. Each operates in the rather narrow temperature range at which it functions best, and each passes its waste heat along to the next lower temperature material which follows it on the temperature scale. While not yet as efficient as lower temperature materials, the new thermoelectric compounds can be used as the top, or hottest, material in such a series. Thus it will permit the entire generator to operate at higher temperature and raise its over-all efficiency.

A self-contained air-conditioned suit which can keep the wearer comfortable in outside temperatures ranging from 40° below zero to 135° F has been developed by scientists of the Westinghouse Electric Corporation and the U. S. Naval Supply Research and Development Facility. The suit is an experimental model for testing the possibility of air-conditioned attire for military personnel and was described by Dr. R. A. Ramey, director of the Westinghouse new products laboratories, and Captain Herman Strock, USN, officer in charge of the Navy facility. Heating or cooling of the experimental garment is done by thermoelectricity, a refrigeration technique that eliminates the need for conventional moving apparatus. Cooling is accomplished simply by passing an electric current through thermoelectric couples made of semiconductor materials. Reversing the current causes the materials to heat instead of cool. The heating or cooling is done automatically, and a temperature of about 80° F is maintained inside the garment. Completely airtight, the suit is made of an insulated aluminum-coated fabric. Air for breathing is supplied through a face mask connected to the side of the suit helmet, where incoming air is heated or cooled by a small heat exchanger. The only moving parts in the suit's entire air conditioning system are two small fans which circulate and distribute the conditioned air around the wearer. Batteries permit the suit to be independent of any other power source for one hour.

Minnesota Mining & Manufacturing Co. announced that a group of leading gas utilities have joined with 3M in a cooperative development program for the design of preproduction prototypes of a thermoelectric furnace generator. At the conclusion of the 18-month program, each of the participating gas companies will receive an operated furnace system in which a thermoelectric generator, converting heat from the furnace combustion chamber into electricity directly, without moving parts, supplies the power required for operating blower or pump motors, making the furnace completely independent of any outside power source. Uninterrupted heating system operation even during a power failure is the main advantage a furnace generator would provide.

The 3M Company emphasized that its commercial interest in the program is restricted to the manufacture and sale of thermoelectric devices and other furnace components and that the St. Paul firm has no intention of manufacturing furnace systems. When the development program is completed, furnace manufacturers will be invited to use the prototypes and the accompanying engineering data as the basis for incorporating thermoelectric generators in their production model furnaces. A prototype will also be submitted to the American Gas Association for testing and approval.

A tiny device that can produce either heat or cold on demand, and so efficient it can freeze or boil a drop of water on power from two flashlight batteries has been developed by Hughes Aircraft Company scientists. The device, smaller than a paper clip, heats or cools at the

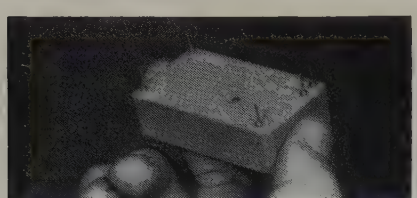
flip of a switch. In clusters, its uses vary from maintaining room temperature in a space ship to operating an instant-defrosting refrigerator with no moving parts.

Hughes has built a 3-stage "cascaded" cooler that brings temperature down to 100° below zero F and is being used to cool an experimental infrared detector. The device requires only two amperes of current.

A heat-control oven is also being built which will hold an even 70° temperature in weather varying from 40 below zero to 180 above while using less power than an automobile headlight. Even greater temperature extremes and higher efficiency is expected as newer materials are discovered.

# New Products

### Counting Device



Sprague Electric has introduced its Series 73Z Core-Transistor Counters. Utilizing rectangular hysteresis loop magnetic cores, these counters represent simple, versatile, and low-cost yet reliable components for counter applications. Counting to speeds of 10 kc, the Type 73Z1 decade counter provides an output signal for every 10 input pulses, then resets in preparation for the next cycle. For higher counting, two or more counters may be cascaded.

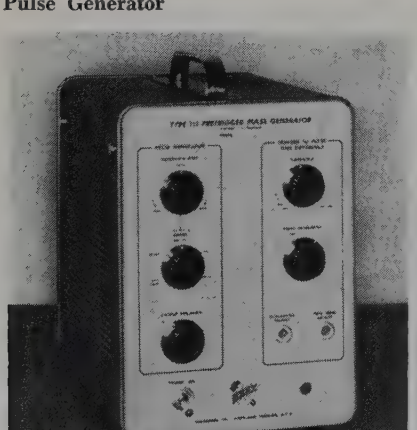
Circle 102 on Reader Service Card

### Flexible Curing Agents

Development of three new flexible curing agents for epoxy resins is announced by The Dow Chemical Company. They are described as amine-terminated aliphatics with controlled and limited functionality. Fewer sites for cross-linking means greater flexibility of the cured mass. Experimental Hardeners X-3483.1, X-3483.2, and X-3483.3 are very low viscosity, almost colorless liquids. Particular application in epoxy coatings, castings, adhesives and laminates is expected.

Circle 110 on Reader Service Card

### Pulse Generator



Tektronix Type 111 ideally suits applications with conventional oscilloscopes or specialized electronic equipment, such as Type N Sampling Plug-In Unit. A high-repetition-rate, fast-rise pulse generator, it provides both output and pretrigger pulses. The output pulses have an amplitude of ±15 volts. Duration is 2 nanoseconds, minimum, and 100 nanoseconds, maximum, at low repetition rates—decreasing to 20 nanoseconds at 100 kc repetition rate. Risetime is less than 0.5 nanosecond. Repetition rate is continuously variable from 10 pps to 100 kc.

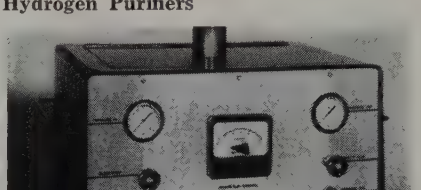
Circle 103 on Reader Service Card

### Wafer Making Machine

Single position button stem and wafer making machine No. 105-BSTI has been developed by Eisler Engineering Co., Inc., to fill the requirements of a small production run on special parts, or for laboratory use and development. All components, lead wires, exhaust tube and glass cylinders are loaded into lower press die. Pre-set fire heats glass parts to proper consistency, then upper press die is lowered by actuating air control valve. Finished stem is removed after rotation is stopped by action of clutch arrangement. Equipped with gas-air-oxygen or hydrogen-oxygen burners to handle all types of glass parts.

Circle 105 on Reader Service Card

### Hydrogen Purifiers



A complete line of economical, easy-to-operate purifiers that produce ultra-pure hydrogen from impure hydrogen sources has been introduced by Milton Roy Company. With this equipment, laboratories and industrial plants can purify hydrogen in milliliters per minute or cubic feet per hour quantities. The unit plugs into any 115-volt *a-c* outlet, pressure and gas flow are adjusted to proper operating range and the pure hydrogen is collected at the outlet.

Circle 123 on Reader Service Card

### Pipet Jars

Design and fabrication changes have been incorporated in the new line of Pipet Jars offered by The Nalge Co., Inc. The new Nalgene® Pipet Jars are now blow-molded in one piece from polyethylene to provide a solid, leakproof receptacle with a minimum of locked-in stress. These versatile, unbreakable jars are ideal for soaking and washing pipets and other glassware, for making stock solutions, for storage, etc. Nalgene Pipet Jars are unbreakable, light in weight, resistant to chemical attack, easy to clean, and economical.

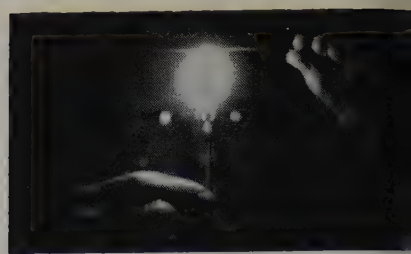
Circle 116 on Reader Service Card

### Germanium Switching Transistor

Sylvania has announced the development of a new germanium switching transistor, an epitaxial mesa unit with a maximum switching time of only 110 millimicroseconds. Designated Type 2N781, the small signal device has a maximum turn-on time of 60 musec and a maximum turn-off time of 50 musec. Its storage time has been reduced to a maximum of 20 musec. Saturation voltage is —0.16 V max.

Circle 104 on Reader Service Card

### Coated Strip For Bonding Semiconductor Devices



Nickel strip coated with a high purity alloy consisting of .6% gallium, the balance tin, has been introduced by Alpha Metals, Inc. This product is the newest addition to the line of fully- and partially-coated strip known as Alpha Continuous Conductive Coated Metals. Chief use of this coated strip is for stamping base tabs to support the silicon or germanium wafer in transistors. The coated area serves as a solder preform to establish a bond between the wafer and the support.

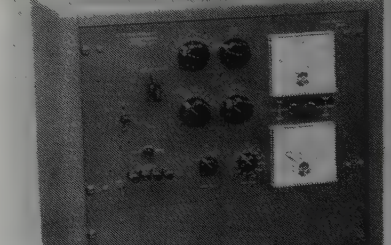
Circle 109 on Reader Service Card

### Solid Tantalum Capacitors

Continuous duty solid slug tantalum *a-c* capacitors have been developed by General Instrument Corporation Micamold Electronics Manufacturing Division. The devices are designed for military, industrial and commercial applications where high reliability and miniaturization are essential factors. They operate at ambient temperature extremes ranging from —80°C to +125°C, and will operate as high as 85°C without derating.

Circle 118 on Reader Service Card

### Diode Test Set



Dynatran Model 1808 measures the forward and the reverse *d-c* characteristics of diodes and rectifiers over a wide range of values. The forward current supply is metered and adjustable from 50 ua to 3 amps. The forward voltage is measured in three ranges of 1, 3, and 10 volts full scale. The reverse voltage is metered and adjustable from 0.5 to 2000 volts. Reverse currents from less than 1 mua to 3 ma are read directly. This test set is power line operated and contains no batteries.

Circle 101 on Reader Service Card

### Silicon Rectifier

Standard Rectifier Corporation has announced a complete line of high-power 400 ampere-rated silicon rectifiers, in stud mounted and flange mounted configurations, to replace several smaller units. Maximum junction temperature is +190°C. Maximum thermal resistance is .1°C per watt between junction and base edge. All units are rated at 400 amperes at 120°C and 160 amperes at 175°C case temperature. They feature a peak voltage rated up to 600 volts.

Circle 121 on Reader Service Card

### ɔoxy Pencil

Cetron Electronic Corporation has de-loped a single-component, no-mix, oxy in pencil-stick form which offers simple solution for most problems in-lving bonding, cementing, sealing and sulating. Encased in a rugged, alumi-um, collet-type holder, it is as easy to se as a ball point pen. The epoxy re-uires no refrigeration or special storage, nd provides a simple to apply, tough, ermanent, waterproof bond which is naffected by most oils and solvents, ring in 7 minutes at 400°F.

Circle 122 on Reader Service Card

### ransistor Cards

A new all-purpose card for transistor ircuits has been developed for the readboarding of semiconductor circuits nd the fabrication of prototype instru-ents and systems. Introduced by Circuit tructures Lab, the E-Z Circuit Cards ridge the gap between preliminary chematic drawings and production-type rinted circuit boards. Development en-ineers may use the cards to prove out heir early designs. The printed circuitry n the E-Z Cards is designed so that a ide variety of analog and digital cir-uits may be developed by simply insert-ng active and passive components, using he pre-drilled holes provided. Card olds 8 complete transistor circuits.

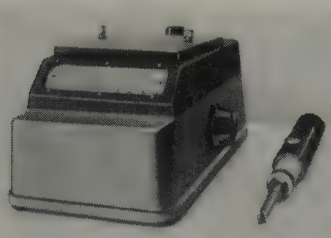
Circle 134 on Reader Service Card

### )ven

Tri Metal's model 0-8 oven consists of a suspended inner muffle surrounded by heating elements mounted on ceramic stand-off insulators. The heating elements are surrounded by a series of polished shields which reflect the radiated heat onto the muffle and thus achieve exceptional temperature uniformity. The outer shell of the oven is water cooled. No water cooling of the door is required. Features temperatures up to 800°C (1472°F); better uniformity—plus or minus 3°C (5.4°F); low-cost, Neoprene "O" ring gaskets guaranteed one year; faster heat up—500°C (932°F) in 23 minutes; closer control—1/C Thermocouple inside the work zone.

Circle 113 on Reader Service Card

### Thermoelectric Probe



Detect differences between metals, alloys, electro deposited metallic coatings, magnetic or non-magnetic, by means of a simple non-destructive test using Electro Impulse Laboratory thermoelectric probe, Model TE-1. Metal bars or sheets which look exactly alike can thus be separated by contacting two points of the metal and noting the thermoelectric power.

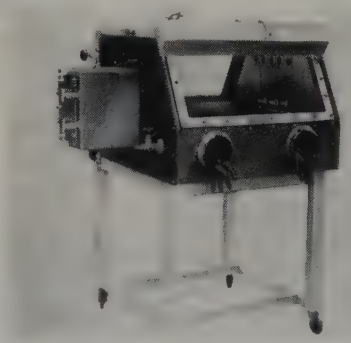
Circle 120 on Reader Service Card

### Automatic Semiconductor Sorter

The TSK Auto-Sorter, imported by Mitsui & Co., Ltd., is a high speed unit which automatically gages germanium or silicon pellets (wafers or dice), and sorts them into the proper categories. A new design enables the sorter to gage and sort 2400 pellets per hour, into any one of 10 categories, with consistent repetitive accuracy to within .000040". A variety of automatic controls is included as standard equipment.

Circle 119 on Reader Service Card

### Glove Boxes



A complete line of double faced glove boxes is available from Kewaunee Scientific Equipment Division of Kewaunee Manufacturing Company. The interior dimensions of a single modular unit are 36" long x 42" wide x 23" high. A great variety of interchangeable parts are available to modify the glove boxes for use as a Controlled Atmosphere enclosure; for Radio-chemistry experimentations; or for Bacteriology or Virology applications. The enclosures are designed with removable end panels, so that by means of a standard connector, two or more 3 ft. modular units can be attached together to provide any length assembly desired.

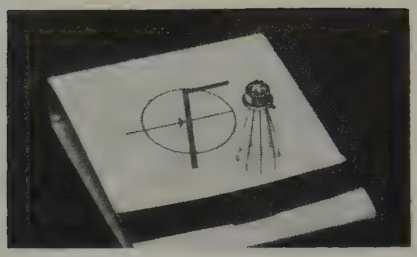
Circle 107 on Reader Service Card

### Centrifugal Blower

The design of the exhaust area of this 2-speed blower for electronic racks permits greater air turbulence over the entire rack interior. This accomplishes faster and more efficient dissipation of heat around semiconductors, crystals and other sensitive components. The unit, manufactured by McLean Engineering Laboratories, is a 19", 500 cfm centrifugal blower that pressurizes the cabinet with clean, cool, filtered air. Various rack depths are available.

Circle 126 on Reader Service Card

### Micrologic Elements



Fairchild Semiconductor Corporation has announced the first of their micrologic Family of devices, a Micrologic Flip-flop. Five other devices, Micrologic gate, half-shift register, buffer, half adder, and counter adapter, will be available during 1961. Together, the six elements, which use direct-coupled transistor logic (DCTL) circuitry, can be used to build the complete logic or arithmetic section of a computer, and are capable of handling logic-function requirements of digital machines operating at bit rates in excess of 1 mc. They dissipate an average power of only 30 milliwatts and will operate over a temperature range of —55° C to 125° C.

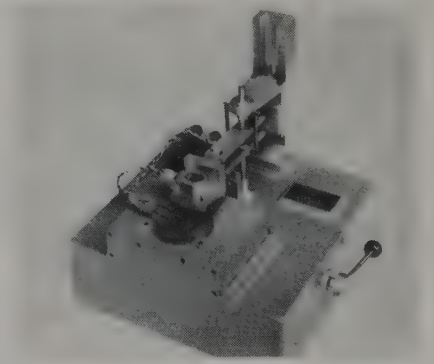
Circle 139 on Reader Service Card

### Firing Control For Silicon Controlled Rectifiers

A controlled time-delay firing circuit, Empire Services' Model 501 Unitrigger utilizes a silicon unijunction transistor (GE 2N1671A) to provide trigger pulses at a precise delay interval from the start of each half cycle. A Zener diode regulates the power supply voltage and allows the timing to be synchronized accurately with the line frequency. The exact delay interval is determined by a d-c control current which governs the charging rate of a timing capacitor. A control current of 3.0 milliamperes is required for maximum output from the controlled rectifiers.

Circle 132 on Reader Service Card

### Resistivity Test Set



Fast and accurate resistivity measurements of semiconductor slices are made possible by the Model C Resistivity Test Set announced by Semimetals, Inc. Unit has been specifically designed for measuring silicon or germanium slices and operation is semiautomatic. Accuracy is within 2%. It utilizes a 4-point probe head. Each probe needle is guided by two ruby jewels, providing a tolerance of +0.01 mm variation in point spacing. Precise, factory-set pressure is maintained on each needle by an individually adjustable leaf spring.

Circle 108 on Reader Service Card

*(Continued on page 72)*

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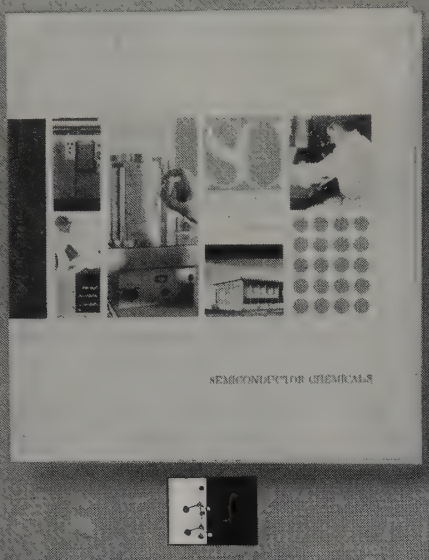

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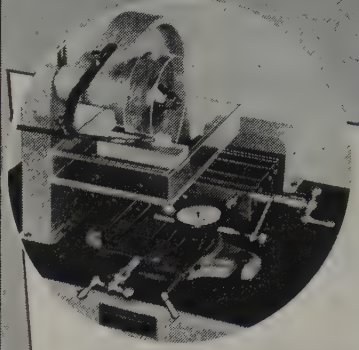
Circle No. 31 on Reader Service Card

GILLINGS-BRONWILL
THIN SECTIONING MACHINE



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Cut sections as thin as .005" practically plano-parallel from blocks ¾" x 1½" x 3" in less than 5 minutes with this 6500 RPM 4" x .012" diamond wheel. Automatic, two direction, precision table feed. Rate of feed set from ⅜" to ¾" per minute. ¼ H.P., 115 volt, rubber mounted motor. Immediate delivery.

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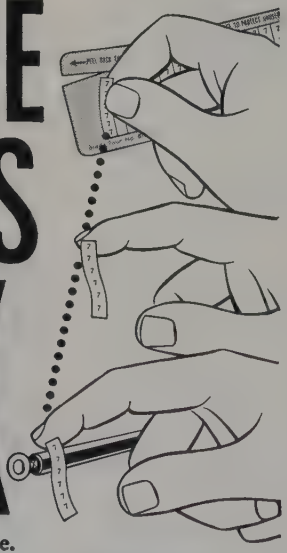

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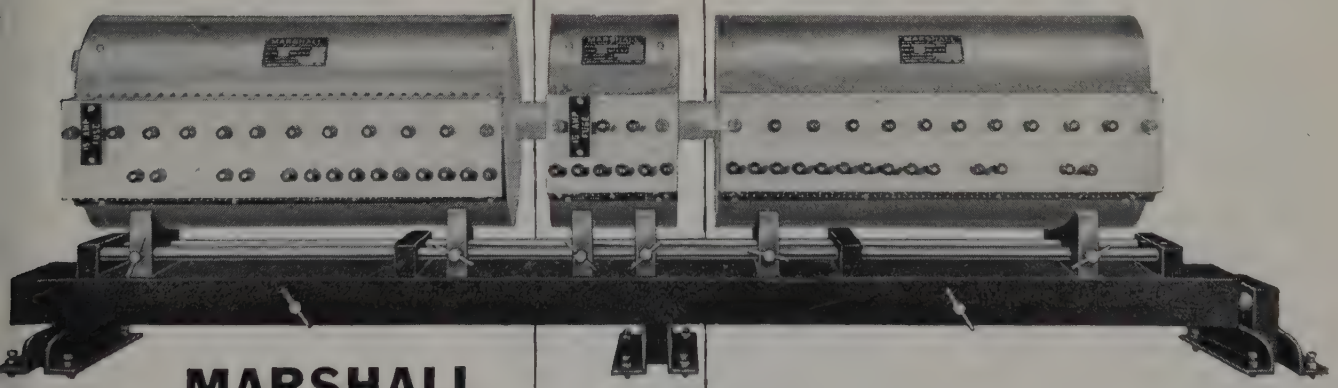
# NEW!

*Typical combination for preparing gallium arsenide consists of 2 furnaces 2"ID x 10"OD x 20" and 1 furnace 2"ID x 10"OD x 6". Note adjustable spacing between furnaces, Thomson rods and ball bushings for linear motion of entire unit.*



## MARSHALL
## furnace apparatus for SEMI-CONDUCTOR PRODUCTION

***...permits zone refining and directional freezing***

Model 60-SC furnace apparatus is designed for semi-conductor preparation and growing single crystal materials. It consists of two or more tubular furnaces mounted on a common axis with a quartz reaction tube running through all furnace chambers. This arrangement permits zone refining and directional freezing of most semi-conductor materials. Furnaces are available in temperature ranges to 1400° C., can maintain uniform zones of ±1° C., and have sufficient shunt taps to establish any reasonable temperature profile within the chamber. Furnaces can be spaced to establish sharp temperature gradients between adjoining units, and can be driven in tandem along the support stand at speeds from ⅛" to 9" per hour. Marshall can supply the complete package of appropriate furnaces, support stand, drive unit, and temperature controls, for horizontal operation (shown above) or in vertical position for "Bridgman Drop" experiments. Ask for specification sheet 825-A.

**Marshall Products Co.** *tubular furnaces and control panels*
270 W. LANE AVENUE, COLUMBUS 2, OHIO

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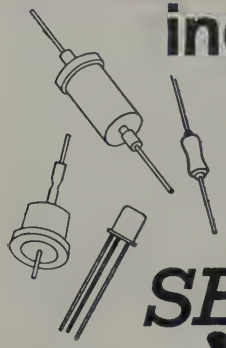

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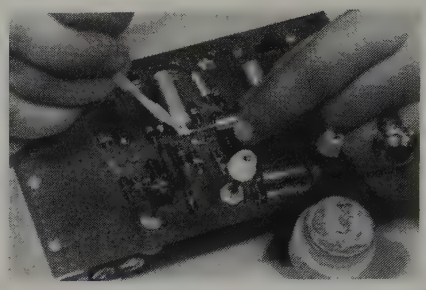
## New Products

*(from page 69)*

### Epoxy Silver Solder



A silver conductive epoxy with a resistivity approaching the resistance of metals between 0.01 ohms-cm and 0.0001 ohms-cm, has been developed by Epoxy Products, Inc., a division of Joseph Waldman & Sons. Epoxy solder can be used at low temperatures for components which are heat sensitive and it has no flux or residue to contaminate sensitive electronic components. It is available in a one component heat curing (as low as 125° C) paste and a two component room temperature cure paste. Typical applications include bonding the tantalum slug to the can of a tatalum capacitor and connections made to heat-sensitive diodes and transistors.

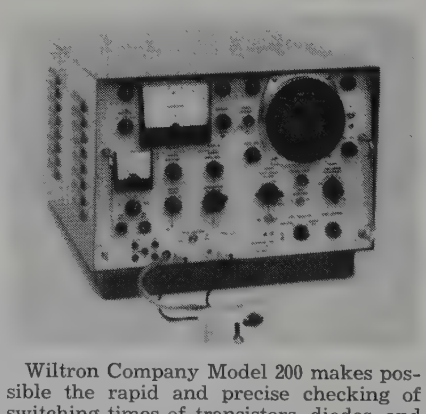
Circle 131 on Reader Service Card

### "Channel" Rectifiers

The Selenium Division of Radio Receptor Company, Inc., subsidiary of General Instrument Corporation, is making available a new series of high voltage selenium channel cartridge rectifiers to 17,000 PIV, with a range of 20 ma continuous duty and 1 ampere surge. Designed for high tension applications such as x-ray, beam welders, precipitators and test equipment, their channel construction makes them especially suitable for applications in oil. Application in air is also possible.

Circle 106 on Reader Service Card

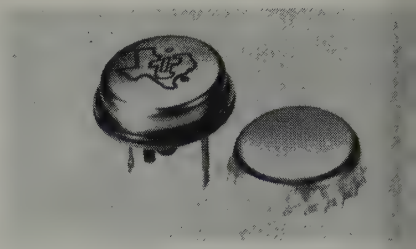
### Switching Time Measuring Instrument



Wiltron Company Model 200 makes possible the rapid and precise checking of switching times of transistors, diodes, and computer circuits. It is primarily aimed at computers with clock rates of from 1 MC to 100 MC. Time intervals from 1 nanosecond to 500 nanoseconds can be measured with accuracies of from 3 to 5%. Provides positionable marker bugs which ride on the oscilloscope waveform and set the time interval for the meter readout. Built-in pulse sources allow a 2 MC test rate with 7 volts into 50 ohms with a 1.5 nanosecond rise time. A completely automatic version is available.

Circle 127 on Reader Service Card

### Germanium Power Transistors



Texas Instruments Incorporated has announced the addition of the "pancake" series to its broad line of germanium power transistors. Features 150 watts dissipation, and a guaranteed 0.5°C/W maximum thermal resistance. Designed for use in computers, converters, regulators, power supplies, oscillators, and any electrical transistorized unit that requires a power supply. Features included are 100°C junction temperature, guaranteed $h_{FE}$ ranges from 20 to 70, and rugged internal and external structure.

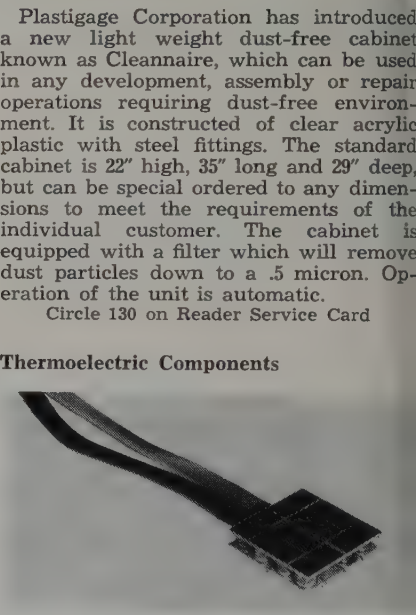
Circle 112 on Reader Service Card

### Dust-Free Cabinet

Plastigage Corporation has introduced a new light weight dust-free cabinet known as Cleannaire, which can be used in any development, assembly or repair operations requiring dust-free environment. It is constructed of clear acrylic plastic with steel fittings. The standard cabinet is 22" high, 35" long and 29" deep, but can be special ordered to any dimensions to meet the requirements of the individual customer. The cabinet is equipped with a filter which will remove dust particles down to a .5 micron. Operation of the unit is automatic.

Circle 130 on Reader Service Card

### Thermoelectric Components



Overheating of "black box" circuits caused by heat dissipation of power transistors and other components can be corrected by various spot cooling applications of new thermoelectric components available frm Ohio Semiconductors, a division of Tecumseh Products Company. Shown above, TA-20 is a "Thermo-Array" of several smaller TA-12 junctions, and is also produced as a finished "Thermo-Module," the TA-20M, with 1/16" thick aluminum plates on top and bottom, ready for use as a complete TE unit. The single module is 1 1/2" x 1 1/2" x 1/2" and of rigid construction. It can pump more than 20 watts, or typically attain a temperature differential ($\Delta T$) between hot and cold plates, in excess of 80° C.

Circle 138 on Reader Service Card

### Silicon Voltage Regulators

A newly-developed, low-cost line of one watt silicon voltage regulators has been announced by the Semiconductor Division of Sarkes Tarzian, Inc. The one-watt, epoxy-enclosed units range from 6 to 105 volts in 20% increments, have a basic tolerance of 20%, with 10% and 5% tolerances available on request.

Circle 114 on Reader Service Card

### Silicon Mesa Transistor

A new silicon mesa transistor, RT5202, with 175 volt collector-base breakdown has been announced by Rheem Semiconductor Corporation. Features include 5 watt power dissipation and a guaranteed $h_{fe}$ less than 10m$\mu$A typical and 2$\mu$A max. at 100 volts. It provides 8 volt emitter-base breakdown and maximum collector capacitance of 15$\mu\mu$f at 10V. $LV_{CEO}$ is greater than 110 volts at 1mA. The alpha cutoff is 30 megacycles and its small signal beta range is from 20 to 100. The unit can be operated in common base with a constant current characteristic to its maximum rated voltage and will switch up to 250 volts in avalanche condition.

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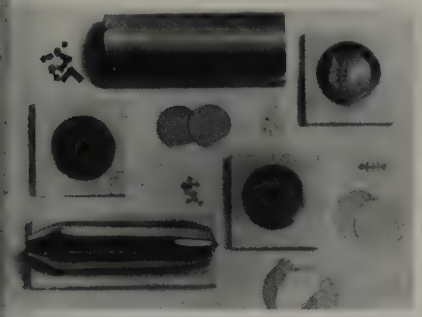
### Semiconductor Materials Processing



Semiconductor materials processing is obtainable from Allen-Jones, Inc., for the slicing, lapping, dicing and ultrasonic cutting of silicon, germanium, ceramics and 3-5 compounds. Slicing is maintained to 0.0005" and better parallel; and lapping to 0.0002". Along with the mechanical fabrication of semiconductor materials a complete service of crystal orientation is available for the electronics, semiconductor and scientific fields.

Circle 117 on Reader Service Card

### Ultra-Fast Switching Diode

Hughes semiconductor division has further refined the performance of its new HD 5000 series silicon diode. The company guarantees a recovery time of half a nanosecond but only to accommodate measuring limits of standard sampling oscilloscopes. The diode's maximum operating temperature has been raised from +100°C to +175°C, and its forward conductance raised from 4 to 10 milliamperes at 1 volt. The ultra-fast switching time was attained through a new formation of the diode junction.

Circle 111 on Reader Service Card

### Microminiature Semiconductor Devices

MicroSemiconductor Corporation has introduced a complete line of Microminiature semiconductor devices made possible by the company's surface passivation concept, which greatly increases reliability as size is decreased. Available in four categories comprising Silicon Micro-miniature Rectifiers (up to 1000 piv ratings), Silicon Ultrafast Computer Micro-diodes (to 2 nano second recovery and 2 micro-microfarad capacitance), Fast Recovery Micro-diodes to established specifications, and General Purpose Silicon Diodes. Encapsulation is not required for these micro-size devices, measuring .075 max. × .030 max. inches. Other features include storage at temperatures up to 300°C and thermal shock resistance over the entire operating range of −65° to +200°C with no delay in transfer and 300 millwatt dissipation rating.

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**DOUBLE FACED GLOVE BOXES**

provide just the right atmosphere for sweet music . . . controlled, of course

This double faced glove box, in spite of its versatility, is standard equipment. And, as the cartoon is supposed to convey, it is designed with tandem viewing panels, glove ports and lighting fixtures thus permitting two operators to work simultaneously.

K · S · E's 32 page catalog clearly portrays these double faced boxes and the many other types of Safety Enclosures available.

** No comment! . . . Dopey's just fiddling around*

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**SEMICONDUCTOR EXECUTIVES $12,000 TO $30,000**

**DIRECTOR OF R&D—to $25,000**

Major multi-division electronics manufacturer needs Ph.D. with strong Physical or Physical Chemistry background to head up R&D group for the semiconductor division. Although heavy emphasis will be on the research side, they prefer a scientist who will take the business rather than the ivory tower approach. Man should have previous management experience, and should have a dynamic drive to get things done. Excellent promotional opportunities.

**DIRECTOR OF ENGINEERING—to $30,000**

Medium size manufacturer of transistors and diodes seeks strong candidate with proven engineering management experience in the semiconductor industry to head up Research, Development, and Production engineering. Although they would prefer a Ph.D., more emphasis will be placed on accomplishments than formal education. Ideal location plus fringe benefits.

**TRANSISTOR DESIGN ENGINEER—$15,000**

New England manufacturer of germanium transistors seeks graduate engineer with three to five years experience in the semiconductor industry to lead a group developing specialized epitaxial transistors such as alloy diffused from feasibility stage through pilot production. Must be able to determine process techniques and mechanical design to evolve a complete package.

**TRANSISTOR ANALYSIS MANAGER—$15,000**

Medium size manufacturer of semiconductor devices seeks graduate engineer with three or more years experience in semiconductor circuits and physics of semiconductors to head up a theoretical analysis and electrical evaluation group. Will be responsible for theoretical semiconductor design, theoretical thermo and electrical analyses of device structures, and for providing electrical evaluation of developmental and production transistors.

**MATERIALS MANAGER—$15,000**

Semiconductor manufacturer seeks graduate Chemical Engineer, Metallurgist, or Chemist, with some studies of semiconductor physics, to head up group providing functional services to product oriented device engineers. Typical project of this group will include study of metallurgy of devices, investigations of alloying, etching and surface passivation, and refinement of crystal growing practice, to improve homogeneity of resistivity and dislocation density.

**PROCESS ENGINEERS—to $18,000**

Have many openings for men with experience on germanium and silicon mesa and planar transistors. These requirements range in salary from $10-12,000 for men with one or two years experience, to $18,000 for men with advanced degrees and four or more years experience. Must have experience in one or more of the following: diffusion techniques, photoresist, vacuum deposition or high vacuum techniques, surfaces, device design, housing innovations (particularly in the miniature field), and contact processes.

**MANAGER OF DEVICE DEVELOPMENT—to $20,000**

One of the major semiconductor manufacturers seeks man with strong background in device development on germanium, silicon, and glass diodes. Man should have a minimum of M.S. degree and five years experience in development and process engineering in the diode field, of which at least two years have been in management capacity.

**PRODUCTION SUPERVISOR—$14,000**

Small, expanding silicon rectifier manufacturer seeks graduate engineer or physicist with three or more years experience in the manufacturing of silicon rectifiers, or high power silicon diodes. Man should know production processes such as diffusion and etching. Will be promoted to Manufacturing Manager as soon as he proves his worth to the company.

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If you are interested in knowing more about these and many other Semiconductor Executive positions available through our services, but don't have a prepared resume, simply jot your home address and phone number on the back of your business card and mail it to:

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8% Tungsten-Platinum and 10% Iridium-Platinum for "S" contacts in glass-sealed Silicon diodes. One surface is roughened to improve contact characteristics . . . Exceptionally good spring characteristics of 8% Tungsten-Platinum permit use of thinner ribbons, with savings in cost . . . Tungsten-Platinum withstands high sealing-in temperatures with little, if any, loss in spring characteristics.

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We make high-purity Gold Wire, accurately doped by the addition of Group III or Group V doping agents such as: Gallium, Antimony, Indium, Arsenic, Aluminum. Where required, objectionable impurities are held to extremely low levels. For example, Copper and Silver can both be kept below a few parts per million. Customarily supplied in sizes .001" .0015", and .002"; other sizes, larger or smaller, are also available.

**Gold Wire for Mesa Bonding**

Carefully drawn Gold Wire, 99.99% pure and exceptionally free from curl, is available in any size down to .0005". Supplied in various tempers as required . . . Recent developments indicate that an alloy of 2% Platinum—98% Gold may be successfully used for this application. It has great strength and stability.

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Specialists in the Unusual

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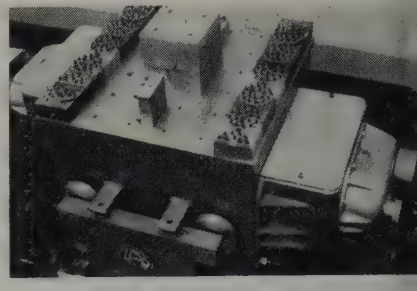
### Glass-To-Metal Seal

Seal-A-Matic has developed a glass-to-metal sealing technique, the "Molecular Sealing Technique," which encompasses not only a modified fusing method, but also includes a new hardening process and a new method of processing terminal pins. Several new quality control checks have been instituted that cull all but the perfect seals. In this technique the glass and metal molecules are bonded at the subatomic level. While this bond is similar to the matched seal, the depth at the glass-metal interface has been increased to provide a much stronger seal, according to the company.

Circle 135 on Reader Service Card

### Vibration Test Equipment



At the Rectifier Components Department of the General Electric Company, Auburn, New York, two reaction vibration machines, Type RVH-18-100, manufactured by the L.A.B. Corporation are being used to test components which must conform to the stringent military requirements for quality control. Once the machines are set for operation, no attendant is necessary. An electric timer system automatically switches the machine off when test period is complete. The tests are conducted at a frequency of 47 c.p.s. and total excursion of 10 mils. The operation produces an acceleration of 10 G's.

Circle 137 on Reader Service Card

### Silicon Transistor

Crystalonics, Inc. announces the silicon field-effect transistor, a three terminal amplifying device with practically infinite input and output impedances. Its amplifying action occurs in the bulk of silicon and is completely removed from the surface, resulting in devices of unprecedented stability. It is a "majority carrier" device and is not affected by changes of "minority carrier life-time" of the semiconductor. Typical switching speeds are 10 nanoseconds, but if voltage gain is required, the external component will limit the speed to about 50 or 100 nanoseconds.

Circle 136 on Reader Service Card

### Power Transistor Heat Dissipator

A new IERC Heat Dissipator, the U Series, is designed to provide positive cooling of power transistors by radiation and convection. Has conventional mounting hole patterns for various power transistor and diode case sizes. The amount of power which may be dissipated by a typical power transistor mounted to a printed circuit board in still air can be increased from 3 Watts to 7 or 8 Watts when the transistor is mounted to the dissipator. This amount may be increased to 30 Watts by placing the transistor, mounted to the dissipator, in a forced-air environment.

Circle 133 on Reader Service Card

# New Literature

Monsanto Chemical Company has announced that it is now making available to semiconductor device manufacturers an evaluation procedures manual for float-zone single crystal silicon. The technical publication describes procedures for measurement of lifetime, resistivity and dislocation density for single crystal silicon. Included is a timesaving and effective method of applying contacts to silicon crystals for lifetime measurement.

Circle 141 on Reader Service Card

Available from the company are 3 pamphlets which describe Tektronix auxiliary equipment. Written in catalog style, with complete specifications, performance characteristics, pertinent illustrations, the 8-page pamphlets give a detailed presentation of: Amplifiers, Square-Wave and Pulse Generators, Time-Mark and Sine-Wave Generators.

Circle 142 on Reader Service Card

"Dow Industrial Service" is an eight-page booklet which describes comprehensive chemical services in areas of equipment and missile cleaning, water and waste treatment and processing, laboratory and technical counseling, product sales and services.

Circle 143 on Reader Service Card

A new edition of the Lepel Induction Heating "Review" features topical and interesting articles on applications, research, and production involving induction heating.

Circle 144 on Reader Service Card

A 2-page data bulletin describing solder clad metals for semiconductor and other applications, is now offered by Accurate Specialties Co.. Inc. Lists overlay materials such as tin, tin-antimony, etc., along with base metals on which these are clad, including nickel, nickel-iron alloys, copper, gold, and silver. Also lists availability in both raw material and finished components, and offers complete specifications as to size and tolerance.

Circle 145 on Reader Service Card

General Electric Company recently published a new specification sheet on silicon high voltage potted rectifier assemblies. The six-page brochure includes information on how to select a potted rectifier assembly and detailed specifications on various rectifier circuits requiring multiple potted blocks. Also included are five charts showing performance of the potted assemblies under various operating conditions.

Circle 146 on Reader Service Card

Philco Corp., Lansdale Division, Semiconductor Operations is issuing a series of Reliability Reports on the various families within their transistor line. Brochures are available on the *SAT* Transistor, which is the second such report to be completed; the initial report covered the *MADT*. Future reliability studies will be announced as they become available.

Circle 147 on Reader Service Card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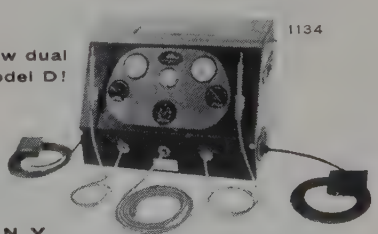


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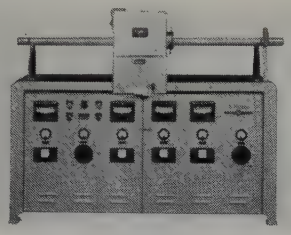
Circle No. 39 on Reader Service Card

**CARL J. JOHNSON**
**Hayes Research & Development Engineer, talks about**

# CRYSTAL GROWING

**HOLDING TEMPERATURES WITHIN ±1°C.** was the chief requirement for a crystal growing furnace designed recently by Hayes for a leading semiconductor manufacturer. Tight temperature control at heats to 1100°C. now assures this manufacturer high yields and high quality . . . with the exact resistivity, type dislocation density, and other parameters specified by their customers.



**THE HAYES MODEL ZL-0316** is a zone leveling furnace employing a new technique for monocrystal production. The heating chamber contains six U-shaped Chromel A strip elements — 3 on top and 3 on bottom — with a hot zone located in the middle. The chamber is power driven at any preset constant speed from 0 to 12 inches per hr., and surrounds a 2¼" quartz tube which extends the full horizontal length of the furnace.

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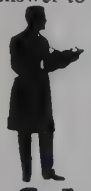

Improve your product quality, cut your costs, increase your production rates — write now for Hayes Bulletin No. ZL-1. C. I. Hayes, Inc., 847 Wellington Ave., Cranston 10, R. I.

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Monitor Systems, Inc., a Subsidiary of Epsco, Inc., offers Application Bulletin #1, 2 pages, which describes a solid state, modular Automatic Transistor Sorter that measures and classifies up to 3,000 transistors an hour and features automatic programming of test sequence by insertion of "specification cards" in the desired order. Block diagram is included.

Circle 148 on Reader Service Card

The first in a series of short-form "hand books" containing information to help design engineers learn how to use the Uni-Tunnel Diode is available. It details the electrical and physical parameters of the Hoffman Uni-Tunnel Diode, testing criteria, and presents typical circuit applications. Hoffman Semiconductor Division prepared this booklet in response to the many questions received since the introduction of the diode.

Circle 149 on Reader Service Card

A four sheet booklet describing the newly announced Silicon Field-Effect Transistors is available from Crystalonics, Inc. The booklet is in four parts. It describes the working principles of the device, it presents the technical parameters, discusses typical circuits, and finally, explains why their stability exceeds that of the conventional bi-polar devices.

Circle 150 on Reader Service Card

Delta Semiconductors has issued a new 1961 catalog of high parameter "Cool Junction" diodes. The catalog covers nearly all standard EIA types in addition to other ultra-fast computer switching diodes, high conductance all purpose diodes and high voltage silicon subminiature rectifiers for commercial or military applications.

Circle 151 on Reader Service Card

"Metalized Mylar Capacitors," a four page catalog describing an expanded line of miniature, hermetically sealed, metalized mylar types suitable for miniaturized applications such as transistor circuitry or printed circuits is available from the Potter Co. Includes engineering data, descriptions and dimensions to cover three series of mylar wrap epoxy and seal types and two series of mylar units in ceramic tubes; all in 200, 400 and 600 *VDCW* ranges.

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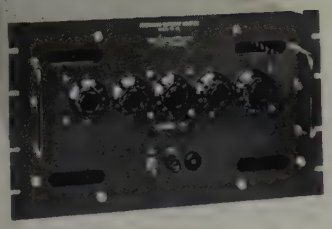

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# Personnel Notes

John H. Phelps has been appointed Manager of Application Engineering for General Electric Company's Semiconductor Products Department in Syracuse, N.Y. He replaces Hugh R. Lowry who recently was named Manager of Engineering for the newly formed signal diode project within the department.

James W. Dibrell, physicist and engineer, has been appointed manager for semiconductor sales at Kulicke and Soffa Manufacturing Company, Inc., Philadelphia, Pa., firm which designs and builds production and research equipment for the semiconductor industry.

Dr. J. R. Stevens, President of J. T. Baker Chemical Company, has announced the appointment of Mr. Walter J. Gerry as Treasurer-Controller. In this position he will be responsible for all of Baker's financial operations.

Nathan Zimmer, President of Accurate Specialties Co., Inc. 345 Lodi Street, Hackensack, New Jersey, has announced that Richard L. Hopkins, veteran management consultant and prominent metallurgical engineer, has joined the company in the newly created position of General Manager.

The appointment of George C. Rayner as Assistant to The President of Allied Chemical's General Chemical Division is announced by Frank J. French, president. Mr. Rayner, with the division 30 years, will direct special projects which will include economic reports and the coordination of proposals for government and industrial contracts.

Roland C. Wittenberg, President of Dynatran Electronics Corporation, 178 Herricks Road, Mineola, New York announces the appointment of James R. Coleman to the position of Sales Manager. The company manufactures a complete line of standard and custom designed semiconductor test equipment for manual and automatic operation.

Dr. Jerrold R. Zacharias, nationally-known nuclear scientist, was elected to the board of directors of the Sprague Electric Co., it was announced by Robert C. Sprague, Chairman of the Board and Chief Executive Officer.

Leonard Bernstein has been named director of research and development at Alloys Unlimited, Inc., Long Island City. In his new position, Mr. Bernstein will supervise the development of new alloys for use in semiconductor devices. Previously, he was in charge of the metallurgy section of the advanced device department of Hughes Semiconductor, where he specialized in alloy development and alloy fabrication techniques.

Micromech Mfg. Corp., 1020 Commerce Ave., Union, N.J., manufacturers of wafering machines and orientation systems, has announced the appointment of J. D. Sorrentino as Executive Vice President and General Manager. He will be responsible for the design and development of devices and machinery used in the slicing and dicing of germanium, silicon and other hard-to-cut materials, as well as orientation systems.

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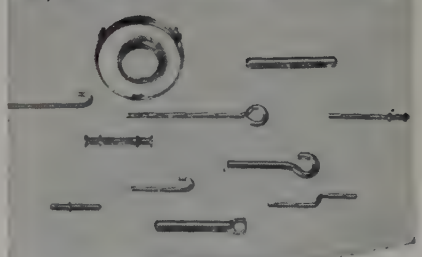
FOR THE HERMETIC SEAL INDUSTRY



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## Graphite Facts

by George T. Sermon, President
United Carbon Products Co.

# Better get the "lead" out!

That's "lead" with a long "e" if you please. I'm talking about *lead time* on semiconductor processing programs. The engineer you put in charge of a program knows how important that can be. Do you?

Right when a new design has been approved and the first few graphite fixtures are being ordered—that's the time to think and plan seriously about future *volume* requirements. After all, if there's no real volume potential for the design, why play with it at all?

That's why your engineer will probably tell you (if you'll listen) that your supplier of graphite parts must have ample *lead time* to tool-up properly to handle a healthy growing program most efficiently and economically. And he'll advise you to choose your source for those first few graphite pilot parts just as though you were ordering 10,000 units.

In sum—settle on the best source for tomorrow—*today*. Work with that source on a long-range basis with proper lead time *built right in*—and your program will be headed for success—right from the start. Here's the right kind of source.

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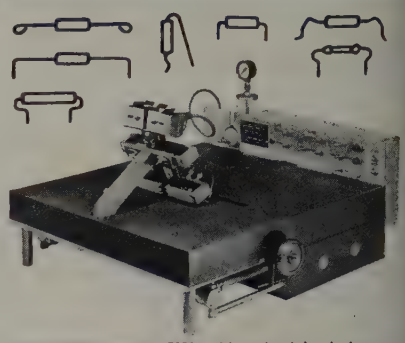
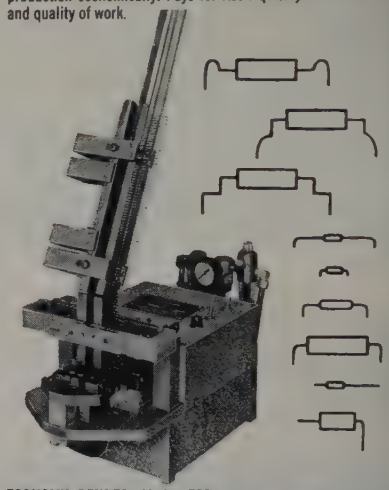
Accurate Specialties Company, Inc.
Aerotronic Associates, Inc.
**Allegheny Electronic Chemical Company ..... 24**
**Allied Chemical Corporation General Chemical Division ... 14**
Allied Radio Corporation
**Alloys Unlimited Incorporated 10, 11**
**Alloys Unlimited Chemicals, Inc. 70**
**Alpha Metals, Incorporated ..... 26**
**American Optical Company ..... 5**
**Art Wire & Stamping Company . 77**
Avnet Corporation
**Baker, J. T. Chemical Company . 3**
Bay State Abrasive Products Co.
Becco Chemical Division Food & Machinery & Chemical Corp.
**Bell Telephone Labs. ..... 30**
Birtcher Corporation, The
Blue M Electric Company
Boonton Electronics Corporation
**Brady, W. H. Co. ..... 70**
Brinkman Instruments, Inc.
**Bronwill Division of Will Corporation ..... 70**
**Burke & James, Incorporated ... 79**
Carborundum Company
Ceramics For Industry, Corporation
Charleston Rubber Company
**Cohn, Sigmund Corporation ..... 74**
Composite Industrial Metals, Inc.
Conforming Matrix Corporation
Consolidated Mining & Smelting Company of Canada
Consolidated Reactive Metals, Inc.
Custom Scientific Instruments, Incorporated
**Davies-Shea, Inc. ..... 73**
**Davison Chemical Company Division of W. R. Grace ..... 16**
**Design Tool Co. ..... 78**
Despatch Ovens Co.
DI-Tran Corporation
Dixon, Wm. Inc.
**Dow Corning Corporation .... 9, 12**
Duramic Products, Inc.
Dynatran Electronics Corporation
Eagle-Picher Company, The
Eisler Engineering Co., Inc.
Electro Impulse Laboratory
Electronic Laboratory Supply Company


*(Continued on Pg 79)*

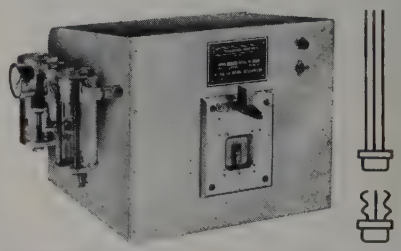

# BOOST PRODUCTION with FME Automatic Machines



**AUTO-FORMER, Model UF2RL,** with optional handy hopper feed attachment, automatically cuts and forms pig-tails (leads of resistors, capacitors, etc.) up to 5000 per hour. This versatile machine will cut and shape any conceivable lead form on any component body with coaxial leads. Handles short-run production economically. Pays for itself quickly in time saved and quality of work.



**ECONOMY BENDER, Model ECB,** cuts and bends all leads automatically to any length up to 5000 per hour. Can be reset in minutes. Prepares leads of diodes and resistors for fast assembly in printed circuits or conventional wiring. Adjustable card feed chute permits rapid loading. Stellite tipped cutters assure trouble-free performance.



**TRANSISTOR STRAIGHTENER, Models AL3S,** straightens the long leads of transistors automatically at more than 1000 per hour, and ejects them from the machine. Leads are not rolled, twisted, or electrically affected in any way.

**TRANSISTOR NOTCHER-CUTTER, Model AL3NS,** straightens, notches and cuts leads automatically at more than 1000 per hour, and ejects them from the machine. Leads are shaped to fit or snap precisely into the proper holes of the printed circuit.

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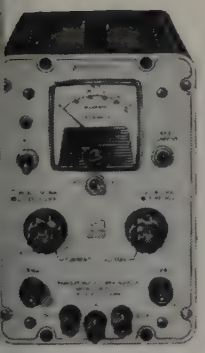

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## INDEX TO ADVERTISERS

*(Continued)*


Electronic Research Associates
**Englehard Industries, Inc.** ..... 23
Epoxy Products
Espey Mfg. & Electronics Corporation, Saratoga Semiconductor Division
Ewald Instruments
Federated Electronics Inc.
Fisher Scientific Co.
Gasket Manufacturing Company
**General Electric Company** Lampglass Division
**Semiconductor Products Department** ..... 18, 19
General Instruments Corp.
**Glass-Tite Industries, Inc.** ..... 8
**Grace Electronic Chemicals, Inc.** 15
Graphic Systems
Greibach Instruments Corporation
Guardian Mfg. & Supply Corp.
Harvey Radio Co., Inc.
**Hayes, C. I., Incorporated** ..... 76
Hevi-Duty Electric Company
Hoffman Electronics Corporation Semiconductor Division
Hunter Tools Company
Indium Corporation of America, The
Induction Heating
Industrial Instruments, Inc.
Institute of Radio Engineers
International Business Machines
Jelrus Technical Products Corporation
**Johnson & Hoffman Manufacturing Corporation** ..... 71
**Kahle Engineering Company** .... 28
Kanthal Corporation, The
**Kessler, Frank Company Inc.** ... 77
**Kewaunee Scientific Equipment** . 73
Kinney Manufacturing Division The New York Air Brake Co.
Knapic Electro-Physics Inc.
Kulicke & Soffa Manufacturing Company, The
L & R Manufacturing Company
**Lafayette Radio** ..... 80
**Lepel High Frequency Laboratories** ..... 79
**Lindberg Engineering Company** ..... 20, 21
Manufacturers Engineering & Equipment Corporation
**Marshall Products Company** .... 71
**Merck & Company, Incorporated Electronic Chemicals Division** . 1
**Micromech Manufacturing Corporation** ..... 13
**Micro-State Electronics Corporation** ..... 76
**Milgray** ..... **Covers IIA, IIB**
Monsanto Chemical Company


*(Continued on Pg 80)*


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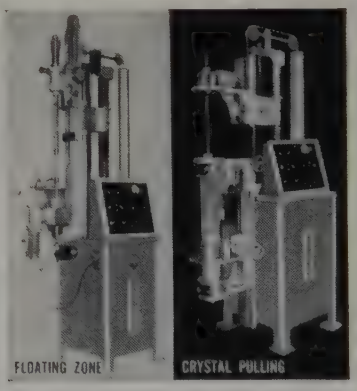


The Lepel Model HCP-D consists of the basic unit with the traverse mechanism and all the controls including the controls for the operation of the generator, and the floating zone and crystal pulling attachments. The same basic support, programming and control unit is used in either adaptation. The major variations are in the attachments and the induction coils. The change from one application to the other can be accomplished in a very short time.

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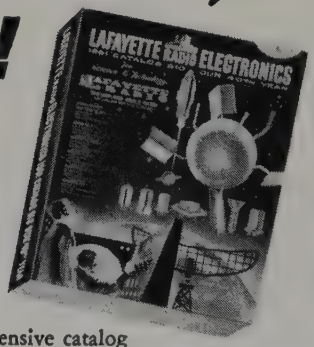


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## INDEX TO ADVERTISERS

*(Continued)*

Mueller Electric Company
National-Tel-Tronics Corp.
Newark Electronics Corporation
New York Air Brake Company, The Kinney Manufacturing Division
**North Hills Electronics, Inc.** .... 77
**Norton Company** ..... 27
Ohio Carbon Company
Optimized Devices, Inc.
PRL Electronics, Inc.
**Penfield Manufacturing Company, Inc.** ..... 22
Pereny Equipment Co., Inc.
**Philco Corporation Lansdale Division** ..... **Cover II**
Pitt Precision Products, Incorporated
**Power Designs, Inc.** ..... 79
**Pure Carbon Company, Inc.** ..... **Cover III**
Radio Receptor Company, Inc. General Instrument Corporation
Raytheon Company Commercial Apparatus & Systems Division Test & Production Tools Semiconductor Division
Reid Brothers Company, Inc.
Rescon Electronics Corporation
Research Chemical Division Nuclear Corporation of America
Ross, Milton, Company
Sandland Tool & Machine Company
**Schweber Electronics** ..... 2
**Secon Metal Company** ..... 72
Semi-Alloys, Inc.
Semiconductor Specialties Corporation
**Semimetals, Inc.** ..... 16
Sonex, Incorporated
**Sprague Electric Company** ..... **Cover IV**
**Sylvania Electric Products, Incorporated Chemical & Metallurgical Division** ..... 4
**Parts Division** ..... 17
**Tektronix, Incorporated** ..... 6, 7
Temperature Engineering Corporation
Textool Products Inc.
Trak Electronics Co. Div. of CGS Labs.
**Tri-Metal Works, Inc.** ..... 25
Trinity Equipment Corporation
**United Carbon Products Company** 78
Unitron Instruments Division of United Scientific Company
Veeco Vacuum Corporation
Wallson Associates, Incorporated
W. M. Welch Manufacturing Company
West Instrument Corporation
Wheelco Industrial Instruments Division
**White, S. S., Industrial Division** 75

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| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 |
| 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 |
| 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
| 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 |
| 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 |
| 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |
| 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 |
| 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 |

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| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 |
| 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 |
| 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
| 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 |
| 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 |
| 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |
| 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 |
| 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 |

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| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 |
| 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 |
| 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 |
| 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 |
| 151 | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 |
| 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 |
| 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 |
| 181 | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 |
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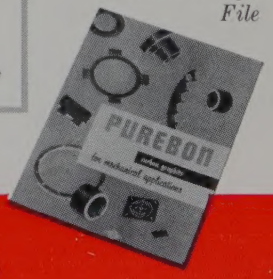


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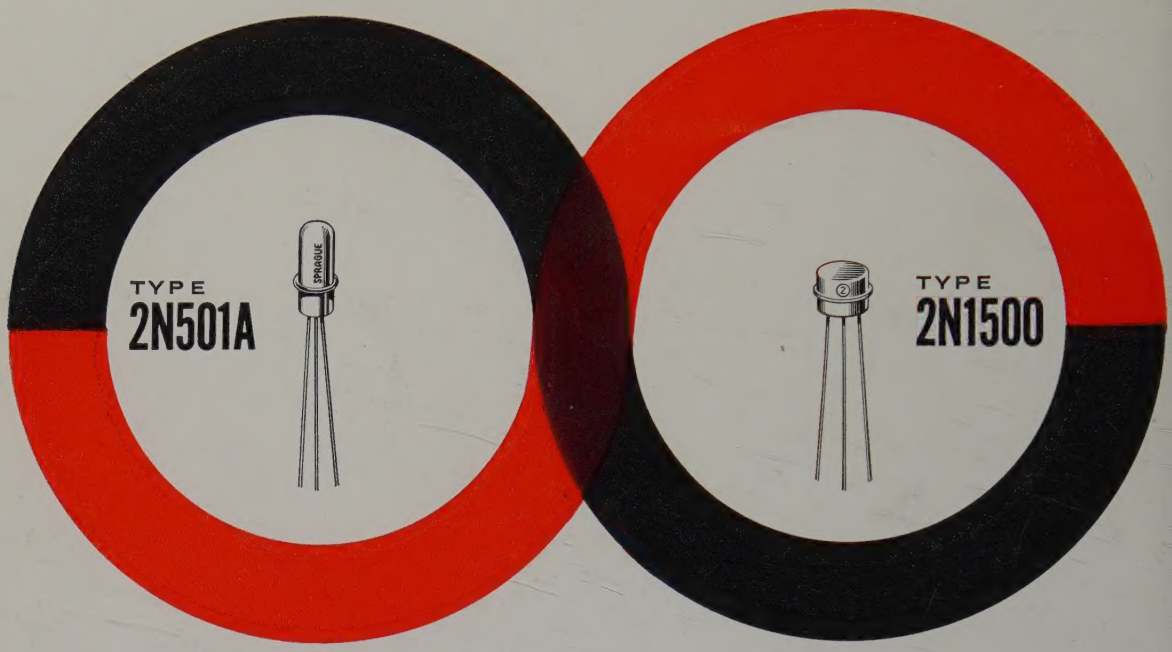


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